WARD

ON

BRICKMAKING.

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BY

HENRY WARD, Assoc. M. Inst. C.E.

WITH AN ABSTRACT OF THE DISCUSSION UPON THE PAPER.

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SECRETARY.

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"Brickmaking."

By Henry Ward, Assoc. M. Inst. C.E.

In hand-brickmaking, as now generally practised, some machinery is nearly always used in the preparation of the clay for moulding the bricks. So long as the brick is moulded by hand it is called a hand-made brick, even though, as with the Staffordshire marls, machinery is employed in the preparation of the clay, and in the pressing of the brick subsequent to its having been moulded by hand. In olden times all the operations of brickmaking were done by hand, including the digging and weathering of the clay; the tempering, the moulding, and sometimes the dressing after the brick was partially dried, though this last operation was seldom performed even with the highest class of bricks.

It is proposed, in the first instance, to describe the mode of brickmaking usually followed in the Home Counties, which is, in the Author's opinion, the best example of brickmaking by hand, though it has often been severely criticised. It may be remarked, that each of the systems prevailing in different parts of the country appears to have been gradually adapted, both to the materials at hand for making and burning the bricks, and also to the value of labour, transport, and such-like conditions, in the locality. The system adopted in the south of England is such that, practically, any clay can be made into bricks from the strong clay in the north and in the south of London, down to that which is little more than sand, as in the Erith district.

The clay is first dug and carried to the wash-mill, where it is mixed with water in about equal parts by volume, and worked up to a thin slurry. In nearly all cases where stock-bricks are made, a chalk-mill adjoins the wash-mill. The chalk is also mixed with water and worked or ground up to a thin paste. Occasionally

one mill is used both for clay and chalk, where the latter is soft and soluble. This chalk is run into the clay-mill, and there it is thoroughly incorporated with the washed earth. The chalk is added to the extent of 10 to 15 per cent. by volume, mainly for the superior colour it gives to stock-bricks, though it also acts as a flux or binding material, without which it would be impossible to make bricks out of some of the very sandy loams now used.

The slurry is mostly raised by elevators or pumps, so that it may run into reservoirs, technically called "wash-backs," about 100 feet square, and 5 or 6 feet deep. When the levels of the field will permit, the wash-mills are so placed that the slurry runs into the "backs" by gravitation. The backs are generally divided into two parts, in order that one part may first be filled, and the slurry in it may thus have more time to dry and be ready for use at the beginning of the season. Where the clay is free from stones, a layer some 3 feet deep is often wheeled direct into the backs before the washed earth is allowed to run in. This saves some of the expense of washing, and also allows the washed earth to become set, ready for moulding, much sooner than would otherwise be the case.

The advantages of washing the earth are great, and may be thus enumerated :—

1. The whole of the brick-earth (and chalk where used) is thoroughly mixed; and this is important where, as is constantly the case, the clay varies greatly in richness.

2. Washing permits the use of brick-earth containing a large proportion of stones.

3. Where clay has to be transported a long distance to the backs, it is much cheaper to pump it through pipes than to convey it by any other means.

Though the clay is thoroughly mixed in the wash-mills, care must be taken to frequently move the point of discharge in the "backs," as the heavier sand has a tendency to sink, and does not flow so evenly over the "back" as the rest of the brick-earth.

The clay sinks and leaves the water on the surface, and the latter is drawn off through an outlet in one of the banks forming the "back" farthest from the point of discharge into the "back." If the site and levels permit, the water returns to the wash-mill, and is used again. As the clay rises in the "back," the gap cut through the bank is gradually filled up with spits of clay. Drains are sometimes (though seldom) formed under the floor of the "back," to assist the water to drain away.

In the case of the very strong clays in London and the immediate neighbourhood, a layer of "mac" is deposited on the top of the clay in the back. This is simply sweepings from macadamized roads. It is used like sand to make the strong clays milder, and to such an extent that, in one brickfield arranged by the Author at Hampstead, as much as 33 per cent. of mac was required to be mixed in the clay to keep the bricks up to their proper size and shape, and to prevent them cracking. Where mac is used, little or no washed clay is admitted into the "back," though usually chalk-water is run on the top of the clay after it has been dug and has weathered.

When the clay has set in the "backs" a layer of sifted house-ashes called "soil" is spread over the top, 2 to 3 inches thick to every foot in depth of clay. Occasionally a thin layer of very fine coke called "breeze" is added to the house-ashes, but with an inferior result, as the heat is then too concentrated, and so often causes the bricks to run together when burning in the clamps.

The pug-mills are placed close to the "back," and by preference some 5 feet lower, so that the clay may be run into the pug-mills by barrows with as little labour as possible. The pug-mills are either horizontal or vertical.

Each moulder has one pug-mill and set of "hacks" under control, the whole being technically called a "stool." Occasionally double pug-mills are used to keep two moulders at work; but the single mills are preferable, as each moulder can then have the pug-mill placed most conveniently for his own "hacks."

All stock-bricks are sand-moulded; that is, the mould is dipped in, and thoroughly dusted with sand after the brick has been made. A moulder has about ten or twelve "hacks" to himself, each "hack" being from 90 to 100 yards long; therefore, as the bricks are stacked eight high, the hack-ground will hold about two hundred thousand bricks when full. The bricks, after becoming sufficiently hard, are all turned over ("skintled") to promote their drying. In summer the bricks are dry enough to put into the clamp about three weeks after moulding.

The clamp is made on the ground with first two layers of burnt bricks, the bricks being spaced about an inch apart. This space is filled with the coarse ashes or breeze sifted from the fine ashes previously mixed with the clay. A layer also of coarse ashes, about 3 inches thick, is spread over the clamp below the green bricks, and occasionally thinner layers are spread between some courses of the bricks higher up the clamps.

The outside of the clamp is covered with burnt bricks, and the

whole of the sides are daubed over with clay to make them air-tight. The clamps hold from two hundred and fifty thousand to three million bricks. Sometimes the fire is started at one end of the clamp, while bricks are still being stacked at the other end, more and more bricks being added as the fire slowly creeps along.

The burnt bricks are, as a rule, divided into three qualities: first come the stock-bricks, which are of a good colour throughout; then the grizzles, which have one side or end of good colour; and last the place-bricks, which are red all over, and soft, through being insufficiently burnt.

When a field is so small that there are only three stools in it, it still pays to have the wash-mills and pug-mills worked by horses; but with larger fields steam-power can be economically used. From seven hundred and fifty thousand to one million bricks per annum are made in each stool.

Two systems of driving-machinery are used in these brickfields, one by shafting, the other either entirely or partly by chains. In most cases where the field is fairly level and of regular shape, driving by shafting is the better plan. When there is but a small thickness of clay, and the field is irregular and uneven, driving by chains is convenient, as these can be led anywhere, and the pug-mills, and even wash-mills, may be changed from site to site as the clay is worked out, with very little trouble or expense.

Plate 1, Fig. 1, is the plan of a brickfield at Plumstead belonging to the South Metropolitan Brick and Lime Company. In this case all the wash-mills and pug-mills are worked by shafting. Owing to the irregularity of the levels, the shafting could not be taken in one straight line; therefore the pug-mills are placed on two different lines, connected together by an intermediate piece of shafting. The pug-mills are each 2 feet 6 inches in diameter, by 4 feet 6 inches long, with eight pug-knives on the shaft. The clay is tipped from a barrow into a hopper at one end, and is continually carried forward and discharged at the other end. The double pug-mills are 3 feet in diameter, and 5 feet 3 inches long, and in these the receiving-hopper is in the middle, while the discharge is at either end; the knives are right-hand at one end and left-hand at the other. A wash-mill is shown, also a chalk-mill at *c*, and slurry-pumps at *d*. The wash-mill is about 24 feet in diameter, with brick sides and bottom. There is a revolving frame made up of a vertical spindle and eight tee-iron arms, tied together with wrought-iron rods, all driven by overhead bevel-

gearing. Three heavy iron harrows, weighing 6 cwt. each, fitted with steel tines, are hung from three of the arms by chains, so that they may just clear the brick bottom, when the mill is empty, and rise and ride over the stones which collect in the mill often to a depth of 2 feet per day. The chalk-mill is about half the size of the wash-mill; it is placed at a slightly higher level, so that the chalk-water may run into the wash-mill. The slurry-pumps are ordinary three-plunger pumps, but made with doors to each valve, so that the valves are easily accessible for removing any obstruction. The "hacks" have movable covers or caps. In some cases fixed covers are used, but though they are better, the extra cost prevents their general adoption. Of the ash- or soil-ground (*h*), a considerable area is required for sifting the ashes. The engine- and boiler-house, *i*, is fitted with a 24 nominal HP. engine and a Lancashire boiler, the latter having a specially large grate for burning the coarser portion of the ashes, no coal being used. Sufficient power has been provided to allow for doubling the present number of stools. The shafting is driven at about 8 to 10 revolutions per minute by gearing; the pulley-speed is reduced by a pinion-and-spur, geared at a ratio of 7 to 1. A well-hole is fitted with a hoist for raising the chalk, which lies about 100 feet below the surface of the ground at this point, and is got by mining in underground workings, similarly to coal. The small chalk is used for the chalk-mill, while the large chalk is burnt into lime in a kiln. The speed of the pug-mill shafting, of 8 to 10 revolutions per minute, is a very uneconomical one. The Author has more than once proposed to alter it by running a much smaller shaft along the backs of all the mills at a speed of 50 to 60 revolutions per minute, using a pinion-and-spur at each pug-mill to reduce the speed. There is a prejudice against this, and it may even be a well-founded one, since some of the shaft-bearings are occasionally covered with clay; they often run without oil, and sometimes a piece of wood is substituted, with a groove cut in it for the shaft to lie in.

When the system of driving by chains is resorted to, chain-gear is erected close to the engine, and it is generally driven by a belt. Plate 1, Figs. 3 and 4 show a good example of this gear. The number of grooved wheels is proportional to the number of pug-mills to be driven, though in some cases one wheel suffices for two pug-mills, the farther being driven through the nearer mill. This, however, should be avoided, as the driving-chain is very apt to slip. The chains can be led off at almost any angle in the horizontal or vertical planes, which is a great convenience, as they are often led

over buildings and up and down hill. This chain-gear is driven through double-purchase gearing, the speed of the vertical shaft being 5 or 6 revolutions per minute.

In some fields the wash-mills and chalk-mills are also driven by chains. These are sometimes made entirely of iron, so that the whole can readily be moved from one site to another as the surrounding clay is worked out, and in this case there is no spur-gearing; the chain drives direct on to a pulley about 14 feet in diameter on the vertical shaft of the wash-mill.

Pug-mills driven by chains are usually of the upright kind, with a 5-feet chain-wheel on the top of the spindle, so that it makes about 4 or 5 revolutions per minute. This is very slow. Probably it was originally suggested as being about the speed at which a horse would turn the mill in walking round it. The chains used for driving are $\frac{7}{16}$ inch in diameter. These though heavy are not more so than is needed, seeing their speed is only 75 feet per minute.

The Author has employed this chain-gear not only to drive pug-mills and wash-mills, but also hoists and pumps in different parts of the field at the same time. To do this properly it was arranged to run the chain at about 250 feet per minute. In this case horizontal pug-mills were employed, but the pug-shaft was kept to a speed of 8 to 10 revolutions per minute by putting the chain-wheel on to a pinion-shaft, gearing into a spur-wheel on the pug-shaft.

As the wash- and chalk-mills are only kept going in the winter, and the pug-mills only in the summer, it has been the custom hitherto to run the chain much faster in winter, when driving the wash-mills, than in summer, and this is done by moving the strap-pulley from the double-purchase to the single-purchase shaft. Of course by arranging, as the Author has done, to keep the chain going at the quicker speed all through the summer and winter, it has been possible to use lighter chains. The chain is supported at intervals of about 15 yards by grooved pulleys, 7 inches in diameter placed on the top of posts 15 feet above the ground. The centres of the driving and driven pulleys should not be less than 130 feet apart, preferably 200 feet, and the chain should not be too tight. It drives better if allowed to sag some 5 or 6 feet between the posts. To prevent the chain slipping round the grooved wheels, six or eight V-shaped clips are bolted to the rims in which the chain may lie. Sometimes single clips are employed bolted on alternate sides of the groove, in order that the chain may be pressed, first against one side of the groove, and then against the

other, thus assuming a slight wave-form. In one case the Author has seen the whole groove cast in this wave-form.

Referring to the system of washing the clay, not only does this prepare it in the best manner, and make it possible to use brick-earth, otherwise valueless; but at the same time by reducing it to the fluid state, it can be pumped long distances through pipes. This is a means of transport seemingly far cheaper than any other. It often occurs, that whereas it is most desirable to make the bricks at the water-side or by the railway-side, the clay to be used is a long distance away. Messrs. Taylor and Neate have kindly furnished the Author with a section of piping $1\frac{1}{4}$ mile long, through which slurry is pumped. The piping is 6 inches in diameter of the spigot-and-faucet kind, laid with lead joints. The clay is washed in a wash-mill, and is then pumped by two sets of three-throw pumps, to either one of two brickfields. These pumps are each 8 inches in diameter by 18 inches length of stroke, and are driven at an average speed of 22 strokes per minute, producing a pressure in the pipes adjoining the pumps of 50 lbs. per square inch. To cleanse the pipes and to prevent them choking by the settling of sediment, every night, before stopping work, for about twenty minutes, clean water only is pumped. This forces out the slurry in front. The water is then allowed to drain out of the pipes, by opening valves at the lowest points, and also by opening air inlet-valves at the highest points, to prevent damage by frost.

Hand-made red-facing bricks are manufactured from clay generally sufficiently free from stones to render it unnecessary to wash it. After being weathered in the winter, this is pugged, moulded, and dried, similarly to the stock-bricks. The red-bricks are burnt in kilns, and these are of various types, sometimes a plain "Scotch kiln" is used, sometimes an open-top kiln, and at others a closed-top kiln. In the last two cases the fire-holes are under the floor of the kiln, and they are fired either from the end or from the side. The floor is perforated for the fire to come through, the whole forming what is known as an up-draught kiln. These kilns are made to hold from ten thousand to fifty thousand bricks. The largest brickmakers in the kingdom are Messrs. Smead, Dean and Co., who make about eighty million annually. Mr. Dean has invented a new mould for bricks, constructed entirely of thin steel plate in place of the old mould made of wood and iron. The new mould is about 1 lb. lighter than the old one. As the workman lifts it four times in moulding each brick, and he makes eight thousand to nine thousand bricks daily, the advantage in reducing the weight of the mould is very great.

Turning now to bricks made entirely by machinery, there are many different systems, and it is difficult to draw any clear dividing lines, except between the two distinct classes of plastic bricks and of dry or semi-dry bricks. The latter differ from the former in that they are made so dry that they can be run direct into the kiln from the machine without previous drying, and can be stacked as many as thirty bricks high at once. All clays can be manufactured into plastic bricks, but only a small portion of them can be made into semi-dry bricks, as for these the clay must be of a marly or shaly nature in order to be ground to small particles. In the mining-districts, and in the North of England, suitable shales and marls are plentiful; in the South, excluding the West, there are only three or four semi-dry brickmaking works. Various attempts have been made to get the more plastic clay through the perforated bottom of the pan-mill. Burnt ballast or ashes have been mixed with the clay, and it has even been partially dried on hot floors before being put into the pan-mill. No practical success has been met with. The perforations in the pan should not be larger than $\frac{3}{16}$ inch in diameter if round, or $\frac{1}{16}$ inch to $\frac{1}{8}$ inch broad if oblong, otherwise the quality of the brick suffers. So long as the clay can be got through the perforations, the wetter it is the better, though the clay should not be wetted afterwards as it would clog and not drop into the mould from the feeding-box. Some shales are so dry that water is added, through a perforated tube, during the grinding in the pan-mill. A rough test as to whether the clay is damp enough, is to take a handful when ground, and squeeze it, when it should adhere and form a ball.

Probably the two greatest difficulties to contend with in semi-dry brickmaking are to grind the clay small enough, and to get it equally moist. Generally 5 inches in depth of loose ground clay in the mould will compress to a 3-inch brick; but there is always an arrangement by which the 5 inches may be increased or diminished, by adjusting the position of the lower piston in the mould during the operation of feeding. This adjustment is a difficulty; it must be varied perpetually, both according to the size of the particles of the clay and to their state of dryness. The drier the clay the less is required to make a brick. In the older type of semi-dry brick-machines the top piston simply dropped on to the clay in the mould, or was forced on to it by steam-pressure, as by a steam-hammer. If therefore there was too much or too little clay in the mould, the resultant brick was either too thick or too thin, though it was always subjected to the same

pressure. In the machines for semi-dry bricks built now-a-days the two pistons have positive movements; thus the brick is always the same thickness, since when giving the final pressure the pistons are always the same distance apart. The clay is often either too little pressed to make a good brick, or too much pressed for the safety of the machine. Two holes are usually left in the top piston, through which any superfluous clay should be squeezed. In actual practice, these holes constantly get plugged with dry clay, and do not act as a safety-valve as intended. It is impossible to feed the clay to the machines constantly in the same state of dryness, or to ensure the particles being of the same size. When the clay is discharged on to the first floor from the elevators, the larger particles drop on the top of the heap of ground clay, and separate themselves from the finer particles by rolling further away. There is generally an attendant to feed the clay into the shoots leading to the machines, or to superintend this being done automatically; still, it is impossible to get equal feeding. In the same way even though all the clay be delivered from the pan-mill equally moist, some of it, owing to its being ground overnight, or, to rolling to the outside of the heap, gets drier than the rest. Thus, the measurement of the clay in the mould wants perpetually adjusting, and at best the bricks must vary in quality. The layer of 5 inches of loose clay is compressed into one of 3 inches, therefore nearly 50 per cent. of the original bulk is air. It is difficult to get rid of this air, but it is generally done by working the machine slowly, limiting the number of bricks made per minute to some fifteen per mould, so as to give time for the air to escape; and it is also done by giving two distinct pressures to each brick, with a slight interval of time between. The second pressure is sometimes obtained by transferring the brick to a separate press, which the Author thinks preferable. It increases the cost slightly, but the brick is of superior quality, partly owing to plenty of time being allowed for the air to escape, and partly also because the press-mould can be kept in much better order than the machine-moulds, as the latter bear the brunt of the work. The wear-and-tear of the moulds and pistons is considerable, especially in gritty shales. A mould has been known to wear out in two or three days.

Where a brick has been subjected to too much pressure, if this be possible, it is almost sure to crack along its face when relieved from the pressure, owing to the escape of the compressed air, which has been shut up inside the brick. Those bricks, however, which are cracked in the machine, if repressed become the best.

In manufacturing semi-dry bricks, to be afterwards treated in a separate press, it is well to make them with a deep frog or recess in the centre, leaving a wall $\frac{1}{2}$ inch thick, standing all round the brick as much as $\frac{3}{4}$ inch high. When this is pressed, a good face is made, as the outside of the brick is squeezed harder than the inside. In completing the brick at one operation, the clay has a tendency to flow from the outside to the centre of the brick, owing to the friction of the sides of the mould, and thus to make the face less pressed than the inside of the brick.

All the pistons of semi-dry brickmaking machines are kept hot by steam circulating through them. The Author does not know to whom this invention is due, but it is a most important one. The heat forms a film of vapour, from the moisture in the clay, on all the metal surfaces, which acts as a lubricant, and enables the brick to leave the mould and piston with clean sharp edges. Should the steam be shut off by any accident, the clay at once adheres to the metal surfaces, and it is impossible to proceed with satisfaction.

Plate 1, Fig. 2, is a plan of the works erected by the Author for the Kent Brick and Tile Company, at Pluckley Station near Ashford, Kent, at a cost of £25,000. The works are connected with the main line of the South Eastern Railway by a siding; *a* is the engine and boiler-house, with machine-house adjoining; *b* is the "Hoffmann" kiln, capable of burning about one hundred thousand bricks per week; *c* is the hack ground for drying the plastic bricks; *d d* are the drying sheds, used principally for blue bricks. These sheds are heated by the exhaust-steam, when the engine is at work. At night live-steam can be blown under the sheds, if it be necessary to work them at the maximum output; *e e* are four Staffordshire kilns adjoining one another; *f f* are two other Staffordshire kilns; *g g* are Scotch kilns for burning those bricks which are dried on the hack grounds; *h* is the main line of the South Eastern Railway; *j* is a siding from the same, leading to the works. This siding is divided into two, the branch *k* being kept on the ground-level, to allow the coals for the boiler and kilns to be brought in conveniently; while the branch *l* is kept about 3 feet below the general surface, that the bricks may be loaded more easily. The floor of the trucks is about level with the floor of the kilns; *m m* is the clay hole, from which the clay is hoisted to the first floor of the machine-house, by an incline 1 in 5.

The clay is loaded into wagons, each containing about two barrow loads. These wagons are carried on four cast-iron wheels, or disks, about 9 inches in diameter by $\frac{3}{4}$ inch broad, fitted with

steel axles 1 inch in diameter. Each axle has one wheel fast, the other loose, thus there is no wear in the bosses of the wheels, except that due to the slight differences of motion of the two wheels, when passing round curves. The advantages of these small wagons over larger ones are: (1) that as the clay varies, in different parts of the clay-hole, a good mixture is effected by using wagon-loads from each part in rotation. (2) As there is a constant stream of small quantities of clay, the mills must be fed a little at a time and often. This saves the break-downs, frequently caused by tipping large wagon-loads bodily into the mill. (3) The wagons are light and handy, so that a boy can manipulate them, slewing them anywhere on the cast-iron floor-plates, and finally turning them over when discharging them. A flat wrought-iron strap, $2\frac{1}{2}$ inches by $\frac{1}{2}$ inch, projects 4 inches above the top of the wagon with a vertical V-groove cut into it. A $\frac{9}{16}$ inch continuous chain is used for hauling, any vertical link of which will lie in the above groove, while the next horizontal link bears against the strap and does the hauling. The weight of the chain keeps it in place in the groove, but the wagons should not be less than 15 feet apart, otherwise they may slip, owing to the chain jerking out of the groove. The rails used are angle-irons, with a very small vertical flange, the gauge being 10 inches only. The endless hauling-chain *n n* passes round a 5-feet grooved pulley, on the vertical shaft of the hoisting-gear in the machine-house at the top of the incline, and round a similar pulley, on a vertical shaft at the bottom of the incline. Two or three other horizontal pulleys are fixed on this lower vertical shaft, from each of which endless-chains are led to similar pulleys and shafts at the working faces of the clay-hole. The full wagons are thus brought along rails from the face of the clay, to the bottom of the incline. Here a boy transfers them to the chain working up the incline. On arriving at the top the wagons disengage themselves from the chain, and after being tipped, are engaged with the return chain and sent to the bottom of the incline, and thence to the clay-face by another chain. The hoisting-chain usually travels about $\frac{1}{2}$ mile per hour. By using cone-pulleys for driving the hoisting-gear, the speed is easily reduced or increased, as more or less clay is required.

Both semi-dry and plastic brickmaking machines are used in the machine-house. Everything is driven from a line of shafting extending from end to end of the house, and running at about 100 revolutions per minute; and all the clay is brought into the machine-house on the first floor. The semi-dry bricks,

after being made and pressed, are run direct into the Hoffmann kiln.

Plate 1, Figs. 5 and 6, represent the pan-mill 9 feet in diameter. This mill is used exclusively for preparing clay for the semi-dry machines. The inner circle shows the solid bottom of the pan on which the rollers run, while all the plates in the outer circle, marked *b b*, are pierced everywhere with fine perforations. The crushed material is then swept from under the rollers on to the perforated plates forming the outer circle, by a plough, fixed to the cross-arm. Those particles which are too large to drop through the perforations are carried back under the next roller by a similar plough or guide.

After the clay has passed through the perforated bottom into the lower pan a rotating arm sweeps it into an elevator, by which the clay is raised to the first floor of the building. It is then passed down through shoots to three Chamberlain's semi-dry brick-machines, and thence to three power-presses.

The Chamberlain machines, though they did good work, were complicated, and needed much repair. They are not made now, and those at Pluckley have been altered, until they somewhat resemble the machine represented in Figs. 7, 8, and 9. These show the machine constructed by Messrs. Whittaker and Co., of Accrington; and, as it is, in the Author's opinion, one of the best machines, he has selected it for illustration. It produces two bricks at one operation, or a total of about one thousand five hundred per hour. The powdered clay is passed down a trunk to the feed-box of the machine. This slides over the moulds, fills them, and returns under the trunk. The upper piston then descends suddenly, the rollers on the connecting-rods having fallen down the straight part of the cam which is on the crank-pin. The slot in the connecting-rod allows this operation, and thus the full weight of the cross-head, pistons and rods, compresses the clay. Time is given for the air so compressed to escape before the final pressure is put on. This is not done until the crank-pin is passing the lowest point; yet this final pressure lasts for one-twenty-fourth of the whole revolution, as the actual vertical movement is only $\frac{1}{3}$ inch during this period. The pressure on the lower pistons is received by the steel cam-shaft, the overhanging portions of which carry the driving-wheels. Cams are cast on these wheels to actuate the levers, giving motion to the feeding-box. It will be seen that the whole strain is taken by the cam-shaft and connecting-rods, the framing carrying only the ends of the shafts. After the brick has been pressed, the action of the central

cam lifts up the brick and lower piston level with the table. The front of the feeding-box, on its forward movement, pushes the brick off the piston. This immediately afterwards, by the action of the cam, drops suddenly, until it is arrested by the balance-lever, ready to receive a fresh charge of clay. The position of the balance-lever is adjusted by a screw, worked by the attendant, and this is altered just as the clay varies in moistness or in fineness of grinding. When the feedbox has moved backwards, the upper piston falls as above described on to the clay, and carries it, the lower piston, and the balance-lever down, until they meet the cam, when the final pressure is given. The lower piston has a large roller fitted to it, against which the cam works, and the whole is protected by a hood from the clay that would drop on it.

The plastic brickmaking machine at Pluckley was made by Messrs. Middleton and Co. It consists of one pair of slow-running hedgehog rollers, into which the clay, after being well watered in the clay-hole, is tipped from the wagons. The clay passes through a second set of quicker running smooth rollers, set much closer together, from whence it drops into a horizontal mixing-trough, fitted with knives, similar to a pug-mill, except that it is open-topped. Should any further water be required, it is added to the clay here, through a perforated pipe, fitted along the trough. The trough discharges the clay into a vertical pug-mill. It is forced from this, in a continuous but ragged stream, through a hole at the bottom. It is here taken, on small carrying-rollers, to two large compressing-rollers 18 inches in diameter, which force it through a Murray's die, in a stream of the same section as a brick, on to a Murray's cutting-table.

Fig. 10 shows a complete machine, as made by Messrs. Clayton, Howlett and Venables, for dealing with rough clays and marls, such as are found in Staffordshire, and from which the blue bricks are made. It consists of a double crushing roller-mill, a horizontal mixing-mill, and a brick-machine. The marls are passed through the crushing rollers dry, without previous soaking with water; the mixing with water takes place solely in the mixing-mill after the crushing. The upper pair of rollers run slowly, and are set about $\frac{3}{4}$ inch or 1 inch apart. They have longitudinal strips on them, to enable the clay to be better gripped. The lower pair of rollers are smooth, and set only about $\frac{1}{4}$ inch apart, and consequently have to run much faster to press the same quantity of clay as the upper ones. All rollers have scrapers working against them, usually held up by weighted levers. The brick-machine has a pair of rollers mounted on the top of the pug.

These are set close together, and force the clay into the horizontal pug under pressure. The pug-mill is fitted with the ordinary knives, except at the end. Here one turn of a screw-blade is fixed on the extremity of the pug-shaft, in order to get the pressure necessary to force the clay through the gradually reduced end of the cylinder, until it issues from the mouth of the die in the form of a brick on to a cutting-off table.

The Author has used a primitive safety appliance for driving the crushing-rollers, in many cases with success. It is impossible to prevent hard stones, pieces of old iron, &c., getting between the rollers. It is better, therefore, to have some means by which the otherwise certain breakage may be avoided. The driving-pulley is loose on the shaft, but drives the shaft through a wooden pin fixed to a lever or arm keyed to the shaft. A wooden pin is turned down as a trial until it just breaks with ordinary work, then a pin twice as strong is substituted. A number of similar pins are kept in stock in case of breakages.

The cutting-off table, where the stream of clay is divided into bricks, is a very important part of the plastic brick-machine, and most of the tables now made are very similar to that invented by Mr. Murray some sixteen or eighteen years ago. The stream of clay is continually issuing from the die, and when it becomes of sufficient length to form ten bricks, it is cut off by a single preliminary wire. The block of clay is then pushed still further forward by hand on to the zinc-covered table, which is kept well oiled with black oil. A lever through a rack-and-gearing forces the block of clay through the eleven wires, forming it into ten bricks, with a waste piece of clay at each end. The bricks are received on a loose board, which is at once lifted bodily on to a barrow, while another loose board is put in its place. The use of a loose board is a great advantage, as it enables ten bricks to be moved at once instead of being handled singly, thus the output is largely increased.

Mr. Pinfold, of Rugby, has devised a cutting-off table very similar to the foregoing; although a little more complicated, it has the advantage that the bricks are cut from the stream of clay, while travelling, and so one of the waste pieces at the end of the block of clay is saved. This is done by mounting the whole table on small wheels and rails to enable it to have a free longitudinal motion while the wires are cross-cutting the clay. The table is pushed under the stream of clay, where it is held firm, until sufficient clay has been received upon it to cut into the required number of bricks. The table is then left free, when the continu-

ally travelling clay carries it along, while the attendant forces the wire through the clay. The bricks are received on to the usual loose board, and the table is again pushed under that portion of the stream which has in the meantime been left without support, owing to the table having been carried away from under the die.

Probably the most important part of the plastic-brick machine is the die, inasmuch as it is absolutely essential to have a stream of clay perfect in shape. Much ingenuity has been expended in devising an immense number of different forms of dies, often apparently without duly appreciating the problem to be overcome. It is frequently seen that a die which will answer perfectly for the clay in one field, will fail for the clay of the field adjoining. No doubt the flow of a plastic material like clay follows very similar laws to the flow of a glacier or of water in a stream, complicated, however, in the case of clay by the fact that different clays have very different coefficients of friction. When a stream of clay, having about the sectional-area of a brick, is forced through a simple hole, the centre of the stream flows faster than the ends and corners, and these, therefore, become ragged and broken. This can be obviated in two ways, either by putting friction on the centre of the stream to retard it, as is practically done very successfully when perforated bricks are made, or by so reducing the friction at the ends and corners, that all parts of the clay flow with equal velocity.

This latter principle is the one sought to be carried out, in Murray's die (Plate 2, Figs. 11 and 12). The ends or sides of the die are made loose, and are held in place by set screws. The inside faces of the ends are made with vertical grooves, and these are covered with moleskin, which can be readily renewed from time to time. The grooves are connected by pipes with small watertanks. The moleskin is thus kept wet, and so lubricates the sides only of the stream of clay. As the nature of the clay may require, more or less lubricant can be supplied by raising the tanks to give a greater head to the water, more of which is forced through the moleskin. A die, also designed on the principle of reducing the side-friction, is made by Messrs. Clayton, Howlett and Venables. The sides of the die are made up of large rollers, which are carried round by the issuing stream of clay. In some cases even, these rollers are rotated by power in the same direction as the clay travels, and rather faster, so the stream is actually helped to issue.

The Author has sometimes found a plain sheath-die answer very well. This consists of an internal and external case, with a space

between; but fitted to one another, so that the front edge of the inner case fits closely to the outer, except up the vertical sides, and just round the corners where a slight opening is left. When the clay commences to issue, water is turned on to the annular space, and passing through only where there is an opening, lubricates the sides and corners only of the stream.

When very thin flat sheets of clay are required, say for roofing tiles, lubricating the ends is of no use. A good stream may be obtained by putting obstructions across the die in the centre, and so retarding its flow. These obstructions must be inserted some 2 or 3 inches back from the mouth of the die, so as to let the clay thoroughly unite again after passing them. Another way of putting more friction in the centre of a thin flat stream is to form the die-plate, say 4 inches thick in the centre, and taper it away to say 1½ inch at the sides.

Besides the semi-dry and plastic systems of brickmaking, another plan appears to be coming largely into use. This is a combination of the above two systems. The clay is prepared similarly to that for the semi-dry process, that is, it is reduced to fine particles in a perforated pan-mill. It has been attempted to reduce the clay to particles by passing it through rollers and a disintegrator; but the Author believes without arriving at any generally successful plan, owing to the difficulty of dividing the clay evenly and finely enough. After passing the mill the fine clay is taken to a small mixer and pug-mill, where it is mixed with just sufficient water to enable it to be forced in a plastic state into a die, and yet with so little that the bricks can be taken at once direct to the kilns, and stacked twenty or thirty high. Plate 2, Figs. 13 and 14 represent a machine of this class, as made by Messrs. Bradley and Craven of Wakefield. The clay is first discharged into the mixer, and a little water added, and is then carried forward to a small vertical pug-mill, from the bottom of which the clay is forced into a pair of dies, in a horizontal revolving table.

The table has an intermittent rotary motion, but it is stationary while the moulds are being filled under the pug. During this time another pair of bricks, which have been previously made, are lifted out of the moulds at another part of the table, by self-acting mechanism raising the lower pistons of the moulds. These last bricks are then carried forward to be pressed in a separate press; the action of so doing pushes forward a pair of finished bricks, which have just been discharged from the press, and they are at once removed to the kiln. All these motions are self-acting, the clay not being touched by hand between the mixer and the press.

Several somewhat similar machines are made in the Leeds district, but the above may be taken as a type of this class of machinery.

Drying Sheds.

Nearly all the best bricks and special goods are made from plastic clay, and are dried in sheds, not in hacks out in the open. In most cases these sheds are artificially warmed by heat applied under a hollow floor. This enables the work to go on in winter, when it would be impossible to dry the bricks out of doors. Sheds heated by ordinary fires are generally from 100 to 200 feet long, the fires being at one end.

In order to get an equal heat all along the sheds, the flues at the fire end are covered with earth some 12 inches thick, which is gradually reduced in thickness until it dies out to nothing about three-fourths of the length of the shed from the end where the fires are situated. It has become the custom of late years to utilize the exhaust-steam from the engines for heating the sheds. This is led under a hollow floor, usually covered with iron plates or stone flags.

Many clays will crack if laid on iron plates. Both these plates and stone flags are costly, and lead to a damp floor, as it is impossible to keep the moisture from coming through the joints. A hollow concrete floor, floated over with cement, has been tried at Otford by Mr. T. R. Crampton, M. Inst. C.E., but it appears difficult to prevent this cracking and letting the moisture through, owing to the expansion and contraction.

The Author, after having tried several plans, has found the hollow brick floors as used at Pluckley the best. By preference a site is chosen rising longitudinally, to allow the condensed water to drain away. A layer of 3 inches of concrete is spread all over the site. Flues measuring 6 inches wide by 4½ inches high, are formed along the floor by laying rows of bricks on edge 9 inches from centre to centre. The bricks are laid with open joints at the ends that steam may percolate freely everywhere under the floor. Paving bricks or tiles, 1½ inch to 2 inches thick, are used to bridge over the flues. A bed of neat cement covers the whole, and on this is laid the final paving-course of hard bricks 2 inches thick. This forms a hard wearing surface, while the cement keeps the damp from rising, and does not appear to crack. The exhaust-steam is taken between the sheds in a main pipe, from which cross-branches controlled by throttle-valves are led, at intervals of about 40 feet. These branches have holes opposite

each flue; should any section of the floor not be in use, the steam can be turned off. Live steam can be turned into these pipes when the engine is not at work.

The drying-sheds at Pluckley are used almost exclusively for making blue bricks. These are moulded as follows, viz., a stream of clay is forced out of a die, and cut by wires into rough blanks; these are taken to the drying-sheds, where, after a few hours, they become dry enough to be removed to the screw-presses, which finish them perfectly to any required shape. No dust or colouring matter is used in making the bricks.

In Staffordshire nearly all the blue bricks are hand-moulded, the clot of clay and the mould being dusted with a material, in which there is a considerable quantity of oxide of iron, to improve the colour. In some places it is the moulding dust alone which gives the blue colour. This is then only skin deep, whereas a good blue brick will be blue for $\frac{1}{4}$ inch in from the surface. Fireclay, or any clay which will stand heat sufficient to melt iron, can always be made into bricks with a blue face, by moulding it in dust containing iron or manganese.

Kilns.

At Pluckley four different types of kilns have been tried, the first, however, Mr. Bull's, being more for experimental purposes than for regular use. This kiln was erected to burn the bricks of which the works are built. It has simply two side walls, similar to a Scotch kiln, with side fires. The kiln is about 200 feet long, by 16 feet broad and 10 feet high, and is worked on the semi-continuous principle, that is, the fires are started at one end, and are gradually worked forward to the other end. The green bricks are stacked in a special manner, and are covered on the top with a layer of 6 inches of clay, in which are fixed small movable cast-iron feed-holes, through which dust-coal is fed to burn the bricks, the side fires being used merely to dry the bricks previously to firing them from the top. To get the draught at Pluckley, two portable sheet-iron chimneys were used, carried on a small traveller spanning the side-walls of the kiln. The kiln was divided at intervals by sheet-iron dampers, stretching across to prevent back draughts, and also to keep the heat close to the bottom by only slightly lifting the dampers above the floor in the first instance. This kiln was badly built of green bricks, and its use was not persevered with after it was decided to erect a Hoffmann kiln. It burnt only 5 cwt. of coals per one thousand

bricks. In India these kilns appear to have had considerable success, though there the system tried was somewhat simpler, the kilns being built on an incline longitudinally about 1 in 8, so that they required no chimneys or dampers to create or to regulate the draught.

Four Scotch kilns are shown on the general plan; these are used for burning plastic-made bricks dried under the hacks. They are simply of the ordinary type, and consume from 8 to 10 cwt. of coal per one thousand bricks burnt. Plate 2, Figs. 15 and 16 represent the plan and section of the kiln, as designed by Mr. Hoffmann. This was carried out, except that the external wall, enclosing the kiln in a building, was omitted, and the chimney was built in the centre of the kiln, instead of at the side; the latter was also built square instead of round as on plan. Plate 2, Figs. 17, 18 and 19 show the chimney in detail as built 170 feet high. The Author would direct attention to this system of chimney-building, which, though common enough in Germany, does not appear to be followed in England. It will be noticed that the brickwork is generally only 4½ inches thick, the walls being built of cellular work. Web-walls, 4½ inches thick, unite at intervals the inner and outer skins, each of which is also 4½ inches thick. The web-walls are joined together about every 10 feet vertically by rough arching or setting over the bricks. Ample stability is secured by allowing a good batter to the external skin, and also a large base. Since the walls are hollow the base can be built with but slight expense. This chimney, as compared with one built according to the usual English practice, has taken less than one-half the number of bricks. The Author attempted to build one of a similar design within the radius controlled by the Metropolitan Buildings Act, but it was not permitted. Another advantage of cellular chimneys appears to be that there is no cracking of brickwork; the inner skin is freer than usual to expand or to contract, while the air-space lessens the strain on the outer skin, and is a good non-conductor of heat. Cement is generally used to build these chimneys in Germany; but the one at Pluckley was built with exceptionally good lime mortar.

This kiln, though it has Mr. Hoffmann's latest improvements, is fired on the same principle as his first one, that is, it is fired continuously. It is fed about every twenty minutes with dust-coal through small holes covered with iron caps in the top. The air for the combustion is heated to a high degree beforehand, by passing through two or three chambers full of burnt bricks which require cooling, while all the products of combustion are passed

through several chambers of unburnt bricks in various stages of burning and drying, until the products finally escape to the chimney with but little more than sufficient heat to cause the necessary draught.

The kiln is now built with fourteen chambers instead of twelve as was formerly the case, to allow of more time for drying the bricks. It is also built oblong with semi-circular ends in place of being perfectly circular, to save room and expense. Extra care is needed to prevent the fire cutting short round the ends. This is effected partly by setting the bricks closer at the inner part of the circular ends to check the draught, and partly also by feeding coal to a greater number of the outer circle of holes than of the inner ones. Each of the fourteen compartments must be provided with a damper to prevent the draught coming backwards. This is usually of sheet-iron, in several parts, placed across the whole section of the kiln, so that it can be withdrawn in pieces through the door just before the latter is closed. The dampers are always fixed opposite the door of each chamber. Sometimes a solid wall is built at the end of each chamber with four or five flues through it, each flue being covered with a small iron plate. These are withdrawn in the same manner as the above large dampers. Instead of iron dampers, Mr. Hoffmann used brown paper pasted all over the bricks across the kiln at the end of each chamber. This is the practice at Pluckley, and it is found to answer very well; even newspapers are sometimes used. The paper lasts long enough to keep all air-tight, and is ultimately destroyed either by the wet steam or the heat, when the nearest damper is raised in the flue leading to the chimney.

As the bricks to be burnt in the Hoffmann kiln at Pluckley are semi-dry ones, when they are put into the kiln they contain about 1 ton of water to each thousand bricks. This has to be driven out before they can be burnt. To assist the process, it was proposed to bring hot air from the chambers, where the bricks are cooling, past those chambers where they are being burnt, and on to those where they are being dried, by an underground flue and suitable dampers. In practice, however, it was found that the whole of the heat of the cooling bricks could be taken off usefully by the current of air passing through to the combustion-chamber. The joints of all the dampers in the flues and feed-hole caps are made by the edge of the metal dipping into a trough of sand. Great care should be taken to lead all flues downwards until the top of the flue is below the level of the floor of the kiln; otherwise the great heat would ascend and destroy the metal. Valves in flues leading from the

chambers in which bricks are actually burning are always kept shut. It is essential to have the floor of the kiln quite dry, and this is best secured by building the floor hollow. About one hundred thousand bricks per week can be burnt in this kiln at Pluckley, with a consumption of 4 cwt. or 5 cwt. of coal per one thousand bricks, which is a very moderate allowance when the amount of water to be dried out of the bricks is considered.

Many attempts have been made to improve the Hoffmann kiln. To save the trouble of loading and unloading the kiln, several different patterns of railway kilns have been used. The ruling principle of these railway kilns is to load the green bricks from the machine on to large railway trucks, each holding say 10 tons. These are gradually passed through a long kiln containing about fourteen trucks until they issue out at the far end. During their passage the bricks go through the various stages of drying, burning, and cooling according to their position in the kiln. The truck has no ends or sides, being simply an iron floor covered with firebrick, supported on four wheels. The floor of the truck is fitted with an iron lip on each side, pointing downwards, and running in a trough full of sand. The trough is formed by an angle-iron built into the side of the kiln, one flange of which stands some little distance from the side of the kiln and points upwards. This makes an air-tight joint between the truck and the kiln. A similar joint is made at the ends of the trucks between one truck and its neighbour. The bricks are piled on the trucks to the same section as the cross-section of the kiln with as little clearance space as possible. Iron doors, sliding vertically, are fitted at each end of the kiln, and are only moved to allow a fresh truck being pushed in at one end, and a finished one taken out at the other end, of the kiln. The wheels and axles are kept fairly cool by the current of cold air circulating underneath. Sometimes these kilns are fired from the side with large coal, and sometimes with dust-coal dropped through holes in the top, similarly to the Hoffmann kiln. It will be understood in the above case that the fires are stationary, and the trucks move. A great effort is necessary to move the trucks, as might be expected, on account of the hot and dirty state of the bearings. To get over this difficulty, Mr. H. Dueberg, of Berlin, has adopted a modification, which consists in allowing the trucks to remain still from the time they are put in the kiln until they are taken out, while the fire moves around continuously as in a Hoffmann kiln. This requires the kiln to be either square or oblong on plan.

Hoffmann kilns have been modified to use gas. None of them,

however, have been built in England, though many have been put up in Germany and in France, and appear to give satisfaction. Gas is formed in any ordinary generator, and is introduced, from below the floor, through vertical perforated fire-brick pipes. All gas-flues are controlled by valves. By means of a flue running along the top of the kiln and movable iron tubes, any two or more chambers can be put in connection with one another, and thus waste heat can be passed from any of the chambers which are cooling to those in which the bricks are being dried and warmed.

The Hoffmann kiln has effected a great change in brick manufacture owing to its burning thoroughly good sound bricks with less than half the fuel before used, yet it is difficult to get any of the higher class of facing bricks burnt in it, as the colour of the brick is generally inferior. It is said that the use of gaseous-fuel overcomes this defect to a large extent. It can hardly do so entirely if the cause of the bad colour be (as is generally understood) the bringing cold air into contact with the hot bricks, after they are burnt, and so cooling them too rapidly.

In the Appendix, Table I. gives the cost of making bricks in the Sittingbourne district and also in the Cowley and Southall district. The bricks are moulded by hand, but the clay is prepared and pugged by machinery. Table II. gives the cost for a whole year of brickmaking per one thousand machine-bricks made at a large works in Yorkshire. The bricks were wire-cut, and were dried under heated sheds in the winter, but under hacks in the open in the summer.

The cost of making semi-dry bricks is somewhat less than the cost of making plastic bricks, but the wear-and-tear and depreciation of machinery are greater. The cost of labour only in making semi-dry bricks is from 7*s.* to 8*s.* per one thousand. Table III. gives the crushing strength of some blue bricks, some semi-dry ones made of slate debris, also of some red plastic bricks.

The Paper is accompanied by numerous drawings, from which Plates 1 and 2 have been engraved.

[APPENDIX.

APPENDIX.

Table I.—Cost of Brickmaking in the Sittingbourne and also in the Cowley and Southall districts, per 1,000 Bricks made.

The clay was prepared by machinery; the bricks were moulded by hand and burnt in clamps, according to the usual London practice.

	Per 1,000 Bricks. Sittingbourne.		Per 1,000 Bricks. Cowley and Southall.		
	s.	*d.*	£.	*s.*	*d.*
Washing and wheeling earth	1	6	0	1	4
Ashes and breeze and wheeling on . . .	2	6	0	2	9
Chalk	0	9	0	1	6
Moulding	4	6	0	4	10
Setting	2	0	0	2	1
Skintling	0	3	0	0	3
Engine, &c., pugging, including fuel and stores	1	0	0	0	9
Sand	0	6	0	0	9
Sorting	0	9	0	1	0
Waste	1	0	0	0	9
Wear and tear, tools and plant, including hack caps and boards	1	6	0	1	3
Foreman	0	6	0	0	7
Rent, rates and taxes	0	6	0	0	6
Royalty	2	0	0	2	0
Total	19	3	1	0	4

Table II.—Cost of Making Plastic Bricks per 1,000 for One Year in Yorkshire.

	Per 1,000 Bricks. Summer, April to September.		Per 1,000 Bricks. Winter, October to March.		
	s.	*d.*	£.	*s.*	*d.*
Wages	9	9¾	0	10	3¾
Oil and grease	1	4¼	0	1	8¾
Coals	2	3	0	4	7
Rates and taxes	0	1	0	0	1
Repairs	0	6	0	0	8
Land (freehold)	1	5½	0	1	6
Interest	1	2	0	1	4¼
Depreciation	0	9	0	0	9
Average each half year . .	17	4½	1	0	11¾

These bricks were dried in the open air during the summer, but in drying-sheds heated by fires in the winter.

TABLE II. (*continued*).—DETAIL of COAL USED per 1,000 BRICKS.

	Cwt.
In Hoffmann kiln per 1,000 bricks burnt	3
„ drying shed „ „ dried	$4\frac{3}{4}$

COST per TON of COALS on SITE.

	Per Ton. s.	d.
Engine coals	16	0
Slack for drying shed	6	6
„ kiln	6	10

TABLE III.—RESULTS of EXPERIMENTS to ASCERTAIN the RESISTANCE to a GRADUALLY INCREASING THRUSTING STRESS on VARIOUS BRICKS.

SIX BLUE BRICKS MADE by J. HAMBLET, WEST BROMWICH.

Dimensions.	Base Area.	Stress in lbs. when Cracked slightly.	Cracked generally.	Crushed, Steelyard dropped.
Inches.	Inches.			
2·74–9·03×4·36	39·24	378,600	532,000	689,220
„	„	355,200	521,800	678,890
„	„	339,100	483,000	668,310
„	„	319,400	411,550	636,180
„	„	311,500	404,600	624,250
„	„	306,800	402,000	603,420
Mean		335,100	459,158	650,045
Lbs. per square inch . .		8,531	11,689	16,549
Tons per square foot . .		548·6	751·7	1064·2

TABLE III. (*continued*).—SIX BLUE BRICKS MADE by WOOD and IVERY, WEST BROMWICH.

Dimensions.	Base Area.	Stress in lbs. when Cracked slightly.	Cracked generally.	Crushed, Steelyard dropped.
Inches.	Inches.			
2·80–8·75×4·12	36·05	168,000	281,000	387,520
„	„	155,000	264,000	382,110
„	„	149,000	258,000	378,230
„	„	144,000	236,000	366,210
„	„	133,000	223,000	347,540
„	„	128,000	211,000	328,620
Mean		146,166	245,500	365,038
Lbs. per square inch . .		4,054	6,809	10,125
Tons per square foot . .		260·7	457·8	651·0

Table III. (*continued*).—Six White Glazed Terra Metallic Bricks made by Wood and Ivery, West Bromwich. (Recessed both sides.)

Dimensions.	Base Area.	Stress in lbs. when		
		Cracked slightly.	Cracked generally.	Crushed, Steelyard dropped.
Inches.	Inches.			
3·10–8·80×4·22	37·14	156,240	168,300	173,460
3·15–8·65×4·20	36·33	141,800	162,140	166,380
3·12–8·80×4·25	37·40	137,500	158,400	164,220
3·16–8·65×4·28	37·02	129,770	148,650	155,340
3·18–8·76×4·37	38·28	113,840	147,200	152,710
3·16–8·70×4·34	37·76	104,120	133,900	140,880
Mean		130,545	153,098	158,832
Lbs. per square inch . .		3,498	4,102	4,256
Tons per square foot . .		225·0	263·7	273·7

Table III (*continued*).—Six Bricks made of Slate debris by the Semi-Dry Process by J. Owen, Glogue, Whitland, South Wales.

Dimensions.	Base Area.	Stress in lbs. when		
		Cracked slightly.	Cracked generally.	Crushed, Steelyard dropped.
Inches.	Inches.			
2·33–8·70×4·25	36·98	355,200	504,000	633,180
”	”	339,500	495,000	618,240
”	”	322,800	488,400	614,770
”	”	309,200	471,000	607,810
”	”	298,000	459,200	588,260
”	”	295,200	452,500	581,920
Mean		319,983	478,350	607,363
Lbs. per square inch . .		8,653	12,935	16,424
Tons per square foot . .		556·4	831·8	1,056·2

TABLE III. (*continued*).—FIVE RED BRICKS MADE by THE ADDERLEY PARK BRICK COMPANY, SALTLEY, BIRMINGHAM. (Recessed one side.)

Dimensions.	Base Area.	Stress in lbs. when		
		Cracked slightly.	Cracked generally.	Crushed, Steelyard dropped.
Inches.	Inches.			
3·20–8·90×4·35	38·71	79,990	112,760	122,040
3·25–9·00×4·40	39·60	97,150	113,600	119,450
3·25–8·95×4·35	38·93	93,640	107,720	118,460
3·20–9·00×4·40	39·60	84,200	104,250	106,400
3·25–8·95×4·40	39·38	68,400	82,740	84,560
Mean		84,676	104,214	110,182
Lbs. per square inch . .		2,157	2,655	2,808
Tons per square foot . .		138·7	170·7	180·5

All the bricks were bedded between pieces of pine ⅜ inch thick; recesses filled with Portland cement.

TABLE IV.—RESULTS OF EXPERIMENTS TO ASCERTAIN THE RESISTANCE TO A GRADUALLY INCREASED THRUSTING-STRESS OF SIX BRICKS, MADE BY CRAVEN'S PATENT BRICKMAKING MACHINES. (Red brick, recessed both sides, "Craven" in recess.)

Dimensions.	Base Area.	Stress in lbs. when		
		Cracked slightly.	Cracked generally.	Crushed. Steelyard dropped.
Inches.	Square Inches.			
2·90–8·75×4·24	37·10	236,300	288,600	328,860
2·95–8·80×4·28	37·66	224,400	281,000	306,920
2·90–8·70×4·20	36·54	201,900	258,000	300,780
2·90–8·75×4·24	37·10	197,000	235,000	271,230
2·90–8·70×4·20	36·54	184,200	227,900	266,310
2·90–8·65×4·15	35·90	172,800	212,400	230,160
Mean . .	36·80	202,766	250,483	284,043
Lbs. per square inch . .		5509	6806	7718
Tons per square foot . .		354·2	437·6	496·3

Bedded between pieces of pine ⅜ inch thick. Recesses filled with cement.

[DISCUSSION.

Discussion.

Sir Frederick Bramwell, President, said the Paper dealt with a manufacture, the product of which entered more into English engineering construction than did any other material, and it was one which, even where stone was cheap, had the great advantage of being shaped ready to hand, and being, when thoroughly well made, trustworthy for all time.

Sir F. Bramwell.

Mr. Henry Ward called attention to the samples of bricks on the table, and tracings of the chain-gear. The latter, he said, represented a mortar-mill with the pan removed, and chain-wheels, about 5 feet in diameter, substituted, so that the chains could be led to any position without guide-rollers, having simply supporting rollers at intervals. The Tables showing the cost of brickmaking had been compiled from the actual cost-sheets. The makers of brickmaking machinery, he was afraid, would say that the cost was too high, but he thought that, as a rule, they did not take into account all the considerations which ought to be borne in mind by those who had to make bricks for profit. Among other items were the interest on capital, the value of freehold land, the renewal of plant, and the sinking fund, which nearly all brick-fields had to allow to repay the capital when the lease expired. With reference to a statement in the Paper that the pistons of some dry brick-machines were kept hot by steam, he believed that in a few instances the moulds, not the pistons, were kept hot in that way. Practically, that was very much the same thing, seeing that the pistons were in constant contact with the moulds, and so became hot. A film of vapour formed on the pistons, which made a lubricating material, and enabled the brick to be easily discharged.

Mr. Ward.

Mr. W. H. Venables said he preferred the plastic process, because of the frequent failure of the semi-dry process, the bricks yielded on the face, and did not stand the weather so well as those produced by the plastic process. Plastic bricks were made with much greater facility than semi-dry bricks. The majority of clays were found wet, and were easily treated as such; but by the dry process they had to be partially dried before they could be treated. As the Author had stated, the semi-plastic process was certainly coming into vogue, and almost every brickmaker was endeavouring to use it. In this process also, however, there was the difficulty of the clay not being in a fit condition to be treated immediately.

Mr. Venables.

Mr. Monson. Mr. E. MONSON had been disappointed to find that the Paper was not entirely devoted to brickmaking. The first part appeared to deal with the stock brickmaking process. No doubt in the neighbourhood of London that system in the past was the best that could be adopted; but at the present time it was nearly going out, and brickmakers wanted to know what they were to do under the circumstances. For stock brickmaking they required wash-mills, breeze, and so on, but those things would not be needed for other processes. Very little description had been given of the machinery employed. He was of opinion that the semi-dry process was that which would be used henceforth in the neighbourhood of London, because nearly all the brick-earth had been worked out; there was none in the north, very little in the south, and in the west it was nearly all exhausted up to the neighbourhood of Windsor. The question, therefore, was how to deal with the London clay. For the semi-dry process it would have to go into a 9-feet perforated pan, and pass through it. The difficulty was that the material as it came from the clay-pit was too wet to pass through the perforations. But that could be got over by drying the clay and by putting in dry materials, such as soft bricks, burnt ballast or clinkers. The process was easy enough. The clay went from the perforated pan into the mixer, next into the machine; then it came out a moulded pressed brick, but it was usually pressed again. He did not think that putting the bricks directly into the kiln would be a good plan, because they would probably fly, not being sufficiently dry; and besides this the steam from the lower bricks would spoil those that were above. Generally it was necessary to put them on drying-floors. The Hoffmann kiln appeared to be a good one, but he was told by practical men that there was no gain, in regard to cost, by that method of burning. If it could be kept regularly at work, burning, say, one hundred thousand bricks per week, it might perhaps be worked with advantage; but to ensure this it was necessary that all the orders should come in in the same regular way. By the old process a field was skimmed 4 feet or 5 feet deep to obtain the brick-earth, which had a good deal of sand in it, so that the bricks dried without cracking. On account of its being deficient in sand the London clay must be worked much drier, so that the semi-dry or the semi-plastic process was needed. In working the London clay, by either of these processes, the machinery was fixed, and it was possible to go to a great depth to get the clay out; but where the field was skimmed the machinery had to be constantly moved about. He considered that the list of machines mentioned

in the Paper was imperfect, many that were in the market not being represented. Mr. Monson.

Mr. F. HOWLETT said the chief difficulty brick-machine makers had to contend with was the great variety in the material to be dealt with. There were the strong London clay, the very sandy clays, the tough leathery blue gault, the hard Staffordshire marls, the shales, which were almost like pieces of rock, and the various fire-clays. They were expected to deal with all kinds of material, and it was no wonder, therefore, that brick-machines were not always as successful as might be desired. He had placed on the table a box of samples of ninety different kinds of clay, all of which had been selected and used for brickmaking purposes, and many more might have been sent. Feeding brick-machines regularly was, no doubt, an important point, especially in the case of plastic-clay machines, for if the clay was not properly put into the hopper, it could not come out at the other end in the form of bricks. That matter was very often overlooked in the brick-yard. Brick-machine makers were often required to explain why a particular machine did not make as many bricks as it ought to do; but on inquiry it generally turned out that the clay had not been constantly put in. When that was insisted upon, the machine made 50 or 100 per cent. more bricks than before. The plan of feeding by small trucks was advisable, because the clay was then thoroughly well mixed. The system of drawing by chain was no doubt very good, but on the steep inclines generally used, often of 1 in 2 or 3, he doubted whether the chains would hold tightly enough. Reference had been made in the Paper to dies, which were lined inside with metal plates, laid over one another like scales, and with water passing between the scales at the corners of the dies. That answered very well in many cases, but he had sometimes found that water would not answer, but oil would, and in several instances, where neither water nor oil were successful, steam had overcome the difficulty. The Author had stated that in Staffordshire the blue bricks were nearly all made by hand. Mr. Howlett thought that many blue bricks were now made by machine. In one case his firm had put up machinery sufficient to make fifty thousand bricks per day, and he knew of several other works in the same neighbourhood where a large number of blue bricks were made by machine. The Author had also said that good blue bricks should be coloured $\frac{1}{4}$ inch in from the surface. Mr. Howlett should not call a brick blue for only $\frac{1}{4}$ inch a good blue brick. The best bricks were coloured blue nearly or quite through. He had that afternoon broken a blue Mr. Howlett.

Mr. Howlett. brick made by the Cakemore Brick Company at Rowley Regis, and it was blue quite through.

Mr. Barry. Mr. J. W. Barry was sure the importance of brickmaking to engineers would be admitted, especially where stone was difficult and costly to procure. In London they had had the great advantage of their predecessors pointing out the value of the London stock-brick, which experience had shown to be as good for engineering purposes as almost any bricks in any part of the world. In the stock-brick the ashes were mixed with the clay; the whole brick was thus burned together and completely indurated by one process of firing; whereas other kinds of bricks were burned by external heat applied to them after they had passed through some drying process, and they were consequently much more dependent than stock-bricks upon skill in drying and firing. What engineers wanted brickmakers to do for them was to produce a brick which would bear a high compressive-strain in proportion to its weight, and in connection with other qualities. He protested against the practice which had been growing of late years of mixing a large quantity of chalk in the preparation of stock-bricks. The plastic clay overlying the London clay would bear a certain proportion of chalk, but unless great attention was given to the mixture a weak brick was produced, which would not stand compression or the effect of weather as the old stock-bricks made fifty years ago did. He regretted that no details had been given of the strength of bricks in proportion to their weight. If such details could be added they would, he thought, be very valuable, because weight was a matter of very great consequence to engineers. Weight over and above that which was necessary to produce a given amount of compressive strength involved waste, not only in labour (because every brick had to be handled and placed in position by workmen), but also waste in carriage, and unnecessary cost in the means of supporting structures, whether by the use of girders and arches such as were so frequently required in large towns, or by unnecessarily large foundations. The best brick for the smallest amount of weight should be sought for. He was not sure that weight was necessarily an index of compressive strength. He had had heavy bricks made by the dry-process, which had not stood a high compressive strain, but had shown a tendency to give way and fall to pieces. With regard to the large frog in the brick, he was much against such deep depressions, which could not add to the strength of the brick, but might add very much to its weakness, besides being the receptacle of a large and wasteful amount of mortar, which was objectionable

in many ways. Mortar was more costly than the material of the brick itself, and if the cavities were properly filled the brickwork when built took a long time to dry; on the other hand, if not properly filled, the brickwork was unsound. A small depression in bricks was no doubt advantageous in giving a key to the mortar, but it ought not to be much greater than that used in the old London stock-bricks. In the next place engineers wanted a brick that gave a suitable surface for securing adherence to the mortar and cement used in putting the brickwork together. They might have a very sound brick, but it would not make sound work unless it had such a surface as would enable the mortar to adhere to it properly, and thoroughly unite all the brickwork. These matters to which he had alluded might appear small, but they were really of very great importance. When it was remembered that for 1 yard of brickwork about three hundred and fifty bricks had to be united by the skill of the bricklayer, and that the cost of the mortar required to unite them had to be taken into account, it would be seen that all such matters of detail were of consequence, and should be attended to by any brickmaker who wished to suit the requirements of the engineer as much as possible. Mr. Barry.

Mr. E. A. Cowper had noticed for many years, with great interest, the gradual improvements in brickmaking machines. He remembered the first application, fifty years ago, of the mole-skin round the main rollers, to prevent the clay from sticking, as introduced by the Marquis of Tweeddale, also a machine by the late Mr. John Hague, which had a flat, circular revolving table with moulds. The clay was intended to be pushed into the moulds, but it did not fill the moulds. It was not known at that time how the mould could be well filled with clay in a proper condition. The imitation of what brickmakers did by hand, namely, smashing the clay in, and shoving it down in the corners, was not very simply accomplished by a machine. In the first place the clay was in a very moist condition, with the express view of lightening the labours of the brickmaker, but there was a great advantage in the handling and drying after the making, if it was in a stiffer condition, and therefore machines were made accordingly, to use the clay somewhat stiffer. In many machines there was a difficulty in filling the extreme corners under sufficient pressure, and the reason was a simple one; the clay experienced much friction against the sides, ends and bottom of the mould, and being semi-fluid it formed, so to speak, a kind of quarter dome in the extreme corners, and this had to be Mr. Cowper.

Mr. Cowper. squeezed down by extreme force so as to form sound corners in the mould. Of late years, however, it had been usual to avoid such great resistances by simply pressing a stream of clay of the section of a brick through a die by means of rollers, when the angles of such stream only had to be brought up sharp by pressure, there being no corners to be filled; then when the solid stream was cut clean off by wires (as now practised), the corners of such bricks were as sound as any other part. The efficient way in which the clay was forced forward through the die, by means of two rollers placed near together, depended of course on the powerful hold that they had on the thin stream of clay carried forward between them, which was sufficient to fill almost any die. Of late, the clay been much better prepared, especially some of the hard clays such as gault, and others of that description. It required to be much broken up, and separated, so that almost every particle might be pulled away from its neighbour, a proper quantity of water being introduced to bring the whole into a plastic condition; otherwise it was lumpy. Every particle required to be wetted before it was brought into a homogeneous state; that was partly done in some machines by cutting up, or crushing with rollers. He thought that Mr. T. R. Crampton had been successful, first in cutting the clay by rollers, making about two hundred revolutions a minute, and then in crushing it through rollers and mixing it with chalk and water. Drying on floors was, of course, a modern invention, and was sometimes done by the steam being turned underneath the floors in flues, steam-pipes not being needed. He had seen several Hoffmann kilns, and had observed one fault about them; they burnt the clay admirably, but many of the bricks had marks upon them, as though the colour had been stopped from developing by other bricks with which they had been in contact. That was owing to the fact that the air was brought upon the bricks while they were at a red-heat, so that any iron that was in the clay in those parts exposed to the air became oxidized and red. Where the air could not get freely to the bricks, they were not so oxidized and coloured. The result was that the bricks had bands and marks across them. That, however, was simply a fault in appearance; and in the case of a garden-wall it looked rather picturesque than otherwise. The bricks were none the worse in quality. Fire-bricks were now sometimes burnt in the long kiln like a lear described in the Paper. The bricks went in at one end, got gradually warm, then thoroughly hot, and then passed out and gradually cooled, the draught of air being in the opposite direction to that of the bricks.

Mr. Arthur Robottom exhibited specimens of bricks glazed with boracic acid, and made from clay found in the neighbourhood of Ongar. Boracic acid, he said, which was formerly sold at £140 per ton, could now be obtained for £23, and glazed bricks, therefore, ought to be sold (according to the Author's Tables), at 70 or 80 per cent. less than their present price. Such bricks were extremely useful in passages and kitchens. Boracic acid was found in Italy. The vapour was forced up from the interior to the surface of the earth, coming into a kind of artificial lake; the water was run off into tubs, and the crystals that formed were boracic acid. Mr. Robottom.

Mr. J. Coley-Bromfield said he was connected with a company that had introduced a brick made from slate débris, millions of tons of which disfigured the landscape in North and in South Wales. It had been stated that London clay was all worked out: here was a clay in a concentrated form, which only required the use of special machinery to convert it into bricks unsurpassed for compactness, durability and strength, and peculiarly adapted for engineering purposes, at a cost about one-third less than ordinary hard red bricks. The shale or waste slate was powdered to very small particles by machinery supplied by Messrs. Whitaker. It then descended through perforated plates into a pit, from which it was lifted by elevators to a stage above, and there forced through a mixing-trough, where a small quantity of water was added. It then passed through another trough into the hopper of the brickmaking machine, and when moulded it was carried straight into the kiln without any previous drying, and there stacked at once; the pressure was so great that nearly all moisture was forced out; so that a kiln could be fired on the very day when the last lot of bricks was put in. The bricks, he believed, were the strongest ever made in the country, the crushing-strain being equal to 1,056 tons per square foot, some not breaking even at that. He also wished to direct attention to a firestone-brick, in which a wrought-iron bolt had been put when the brick itself was burning, to ascertain what heat it would stand. The brick, it would be seen, was perfect; but the iron bolt had been melted into it. He believed that those bricks would stand the strongest heat ever required for steel furnaces, and several works had been supplied with them. Some of the slate bricks had been sent to London and sold for the foundations of a church at Rotherhithe. The company's present works was the only establishment of the kind; but licenses had been given for others in different parts of the country. Amongst its customers were Mr. Bromfield.

Mr. Bromfield. the Great Western, the London and North Western, the Mid-Wales, and the Cardigan and Whitland Railways. At the International Inventions Exhibition the company's brick was the only one that gained a medal.

Mr. Giles. Mr. A. GILES, M.P., had been somewhat disappointed with the figures given by the Author as to the cost of brickmaking by machinery, as they appeared to show very little saving in labour as compared with the old hand-process. It would seem from the figures that the cost of labour employed in making bricks by hand was about *9s. 6d.*, as against *9s. 9¾d.* for one thousand. It was well known that there were bricks and bricks. When a contractor bought a thousand bricks, he wanted first to know their size, because a brick might be very good, but it might be of such a size as to make 15 or 20 per cent. difference in a cubic yard of brickwork. There had been a wonderful development of the brick-trade since the duty had been taken off. He remembered buying a large quantity of bricks when *5s.* a thousand was paid for duty, and the whole cost was only *28s.*, including the duty and cartage to a distance of 3 miles. Seeing that machine-made bricks now cost *17s. 4d.*, and hand-made bricks *19s. 3d.* per thousand in the brick-yard, there did not appear to be much reduction in price since the time to which he alluded. Considering the perfection which machinery had attained, he thought the price ought to be cheaper. There was certainly an advantage in making bricks by machinery, as brickmakers were by no means the most desirable set of men to deal with. They were hard-working and hard-drinking men, given to strikes, and very difficult to manage. Their task was certainly most laborious. One man at a stool would make from eight thousand to nine thousand bricks in a day, and for that purpose he would have to turn out ten bricks every minute from the mould during fifteen hours. Considering the exhaustion produced by such work, it was no wonder that the men were occasionally unruly.

Mr. Ward. Mr. H. WARD, in reply, said it was no doubt advisable to have a light brick for many purposes; but for some purposes, such as foundations and retaining-walls, it was better to have a heavy one. Of course, where stress was put on foundations, as in the case of chimney-building, it was important to have as light a brick as possible. Mr. Venables had remarked that it was necessary to dry clay artificially before it was used in a semi-dry brick-machine, or passed through a pan. That was not so. He knew of only two works in the country where that system was used. He believed it had been employed for a time at Mapperly, in Notting-

hamshire, where some clay which was too plastic to be ground through a perforated pan-mill, was partly dried on a steam-heated floor on its road to the machine-house. At Pluckley, during the winter, it was constantly found that the clay was too plastic to go through the pan, but there was a very ready mode of getting over the difficulty, namely, by mixing a little burnt ballast, or even ashes in some cases, with the clay. The Hoffmann kiln needed no defence from him. It had certainly reduced the consumption of coal to something like one-fourth, or one-third what it was. It had burned bricks with 2 or 3 cwt. of coal per thousand, whereas the Scotch kiln used to burn 8 or 10 cwt. True, the colour was not first-class, as had been stated, but the bricks were first-rate for engineering purposes. It had been said that during the last two or three years the difficulty had been overcome to a large extent by the use of gas as fuel, but he was a little doubtful on that point. The difficulty arose, he believed, as Mr. Cowper had explained, by bringing the air in contact with red-hot bricks, which no doubt had a great oxidizing influence. In other kilns, where it was important to have a good colour, it was the custom directly the bricks were burnt to close up every inlet to the kiln through which air might come, so that the cooling process often took three or four days; whereas in the Hoffmann kiln the cooling was very rapid. As to the size of the brick, he thought that bricks should be bought by the cubic yard rather than by the thousand, so that contractors would know exactly what they were buying. Bricks in Scotland were made with the joint 4 inches thick; in Yorkshire with the joint $3\frac{5}{8}$ inches; in Birmingham about the same; towards the south they varied from 3 inches with the joint to 3 inches without it. Those who bought bricks should be careful in getting the exact size, or a guaranteed measure per thousand. As to blue bricks being coloured right through, he believed that was the rarest thing possible, and the reason was not difficult to comprehend. That which gave the colour to the bricks was practically the melted oxide of iron, and it was impossible to get the heat inside the brick without over-burning the outside. At any rate very few clays would stand that heat. If a brick was blue a $\frac{1}{4}$ inch in, it was a thoroughly good brick. If a brick was blue right through it would generally be found that the outside was more like a cinder, having had all the substance burnt out of it; it would be twisted and distorted, and probably cracked through. It would be news to Londoners to hear that stock-brickmaking was going out. Machine-makers had been trying to introduce machinery for plastic clay in the

Mr. Ward.

Mr. Ward. London and southern districts for many years, but practically with very little success. Stock-brickmaking still held its own, and he believed would continue to do so. Its advantages were very great, especially in the neighbourhood of large towns; the chief advantage being that practically no fuel, ordinarily so called, was used. House ashes could be had for nothing, and even for less than nothing, for he had known a case in which 3*d.* a cart-load was paid for permission to deposit them on a field. While that was the case it was very doubtful whether any kiln-bricks would supersede the London stock-bricks, at any rate in the southern districts. With the stock-brickmaking process it was possible to use clays that could not be employed by any other process—clays so rich that it would be very difficult to make them by a machine for plastic clay, or in any other way, because they would be cracked and distorted in all directions; some of them being so sandy that persons not accustomed to them might think it impossible to use them at all for bricks. The result was accomplished by the mixture of chalk and other substances with the clay. In accordance with the suggestion of Mr. J. Wolfe Barry, he submitted the following particulars of the weight per 1,000 of different bricks that had been tested. As the bricks varied in size, it had been necessary to calculate the weight of the bricks for the standard size of $8\frac{3}{4}$ inches by $4\frac{1}{4}$ inches by $2\frac{5}{8}$ inches from the actual weight, otherwise a fair comparison of their weights and strengths could not be made.

Bricks made by	Approx. weight per 1000. Cwt.
J. Hamblet	68
Wood and Ivery	70
J. Owen	56
The Adderley Park Brick Co.	56
Bradley and Craven	77

The weight of London-made stock-bricks, of the above size, was about 48 cwt. per 1,000.

Correspondence.

Mr. Hill. Mr. J. W. Hill observed that the method of making bricks by hand was too well known to need notice, except as to the extraordinary tenacity of life exhibited by this ancient process. On the other hand, bricks produced by the semi-dry process had not stood the test of time nearly so well as their ancient compeers, the mode of their manufacture inducing disintegration in a compara-

tively short time; semi-dry bricks were also porous and absorbed moisture, causing damp walls and percolation. The direction in which machinists of the present day were progressing, was that of the semi-plastic process, the happy medium between the hand-made and the semi-dry processes. The Author had not mentioned the brickmaking machine with double screws; this had the great advantage over the single-screw machine of performing twice or thrice the work on the clay in a given time. The body of the former machine was considerably shortened, and the clay rendered more thoroughly homogeneous than by the single-screw machine. Nearly every brick-maker had his own pet form of brick-die, but one of the simplest and most effective was a plain parallel water-die made of soft wood, with a depth of about 9 inches from back to front, and lined with fustian in one piece, tacked round the back of the die and left perfectly loose towards the front of the die. A groove was cut round the wood-work inside, about $\frac{1}{2}$ inch wide and $\frac{3}{8}$ inch deep, to allow the water to flow from the water-can all round the die between the wood and the fustian. By leaving the fustian loose, as above described, it was always perfectly smooth, and did not form creases as it did when the fustian was secured, nor did it wear out so fast. The pressure of the clay on the fustian prevented the water escaping too rapidly from the die. In all methods of brickmaking, the utmost attention should be given to the proper digging, weathering, watering, and pugging of the clay. The action of weather and water performed many most important functions, which could not be exactly imitated, nor the same effects produced, by machinery; and even where this work was attempted by machinery, it was performed at a cost of plant and wear-and-tear far in excess of the natural processes of weathering and watering. Many intractable clays became amenable to treatment by machinery if allowed to soak with water or steam for a few days. With many clays, bricks could be produced by a double-screw machine with the fustian die at 12*s.* per thousand, including all expenses except rent, royalty, and first cost of plant. Mr. Hill.

Mr. A. W. Itter remarked that, in manufacturing semi-dry bricks, a great improvement was effected by having a revolving screen placed on the floor above the machine, so that the elevators might deliver the clay from the perforated pan direct into the screen. The finer particles of clay which fell through the screen were used in the ordinary manner to make bricks; while the coarser particles which passed out at the end of the screen, were returned to the clay-pan to be re-ground. The output of the Mr. Itter.

Mr. Itter. machinery was increased as larger perforations were used in the clay-pan, and the quality was better than where no screen was used, as the particles were more uniform.

Mr. Wedekind. Mr. Hermann Wedekind stated that he had been for many years closely connected with Mr. Hoffmann and the kiln bearing his name. He differed from the Author as to the cause of the so-called bad colour of bricks. The attempts in England to exclude the air after burning, by building permanent brick walls at the end of each compartment, leaving only sufficient openings at the bottom to allow the air needful for combustion to pass along the floor, did not cure the evil complained of. In Germany, on the other hand, where the bricks were generally stacked drier, and heated and afterwards cooled more gradually, a very good colour was obtained. Besides, the gas-kiln referred to by the Author worked exactly on the same principle as the Hoffmann, except that for fuel a large number of gas-jets was substituted for the small coal. In his opinion, the discoloration of the bricks was caused solely by the steam discharged from them while heated, producing with the carbonic acid of the fuel a chemical action, which showed itself even after burning by discoloration, or by forming a kind of scale. With regard to machinery for semi-plastic bricks, English engineers had taken the lead for many years. Amongst others, Messrs. Bradley and Craven, of Wakefield, had supplied their machines to the collieries with marked success, especially in Germany, utilizing the shale as raised to the pit's mouth.

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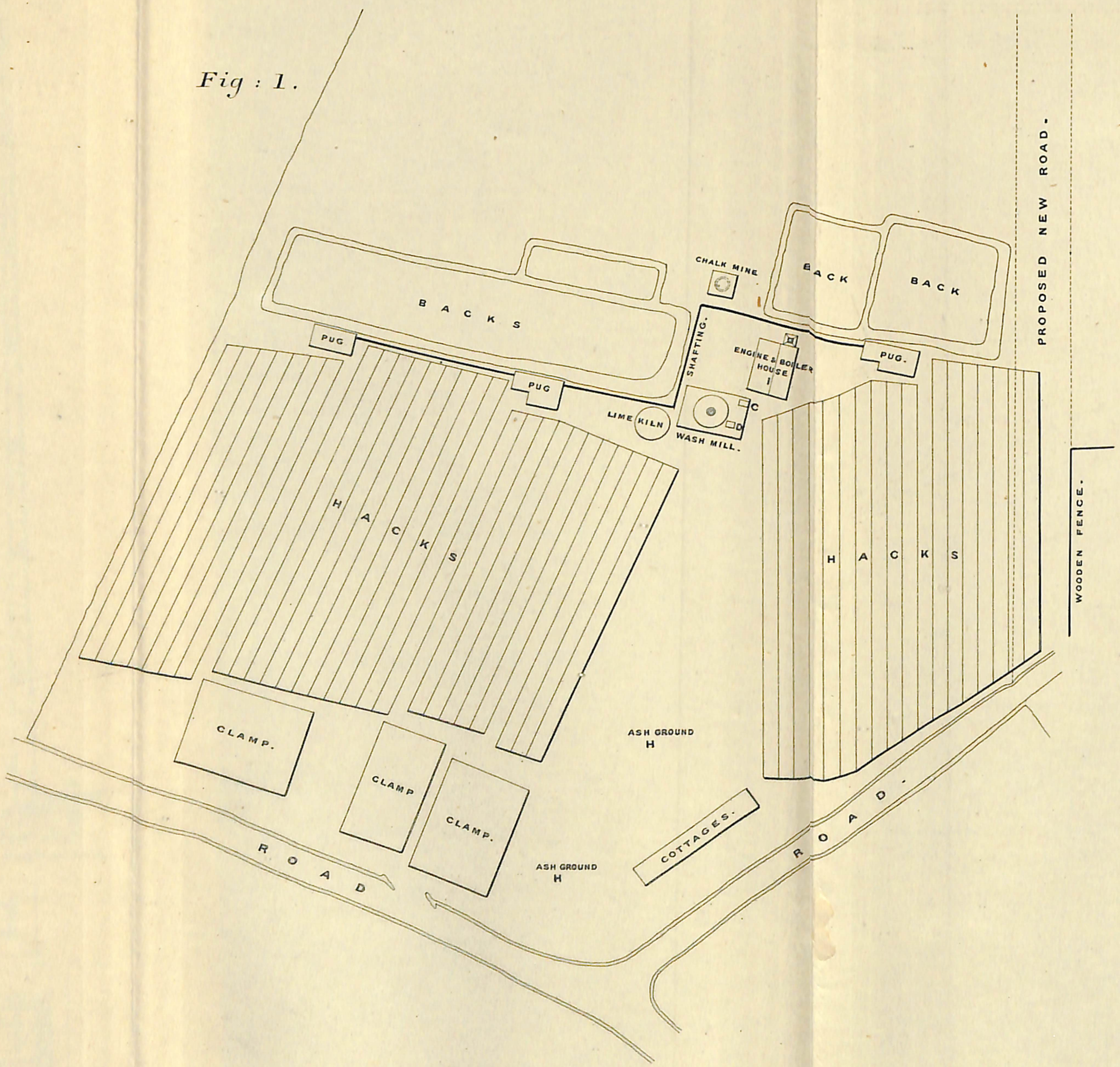
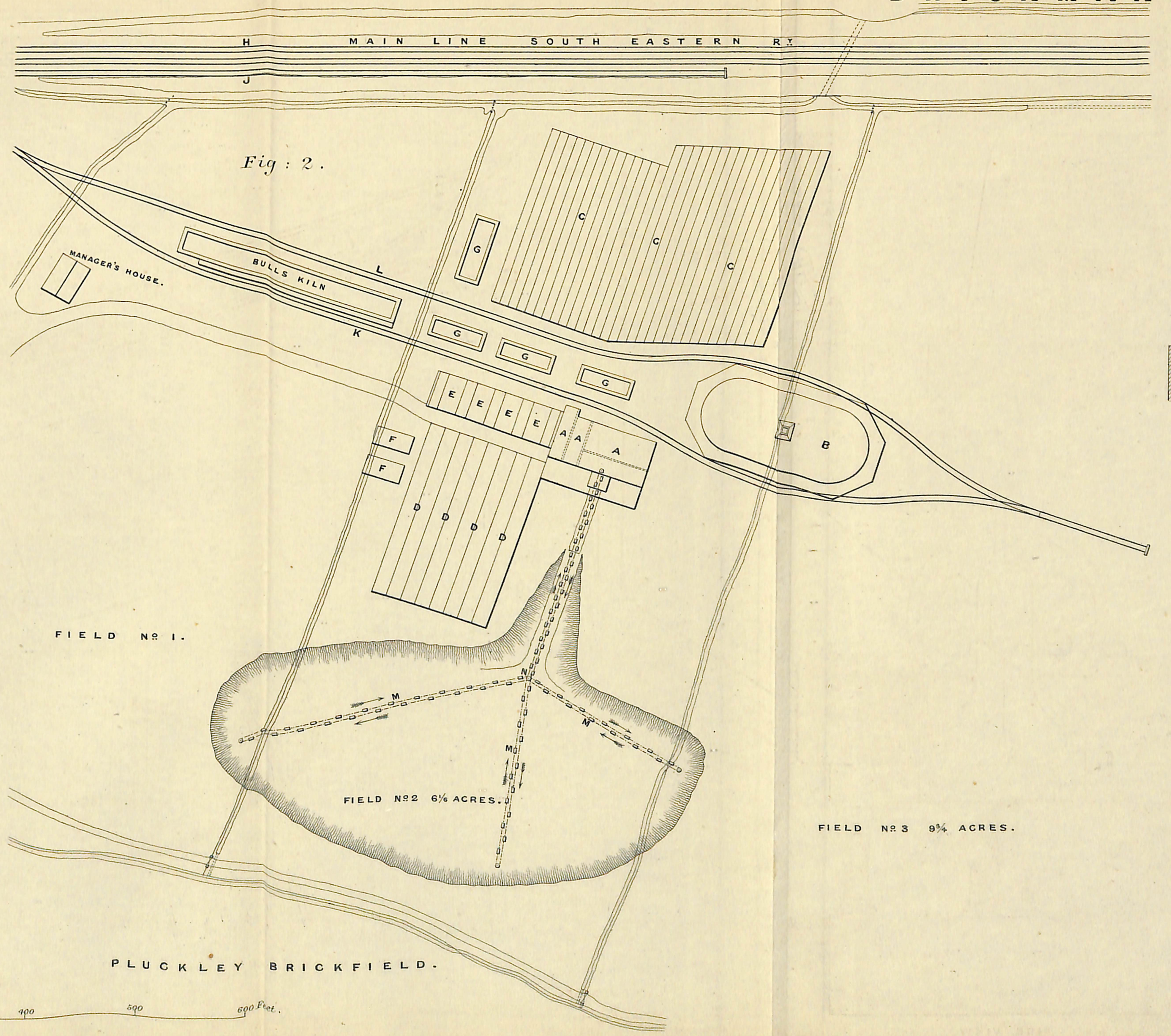
Fig: 1.



SOUTH METROPOLITAN BRICKFIELD.

Fig: 2.



PLUCKLEY BRICKFIELD.

Scale of Feet.

10 5 0 10 20 30 40 50 60 70 80 90 100 200 300 400 500 600 Feet.

HENRY WARD, DEL T.

Fig: 3.

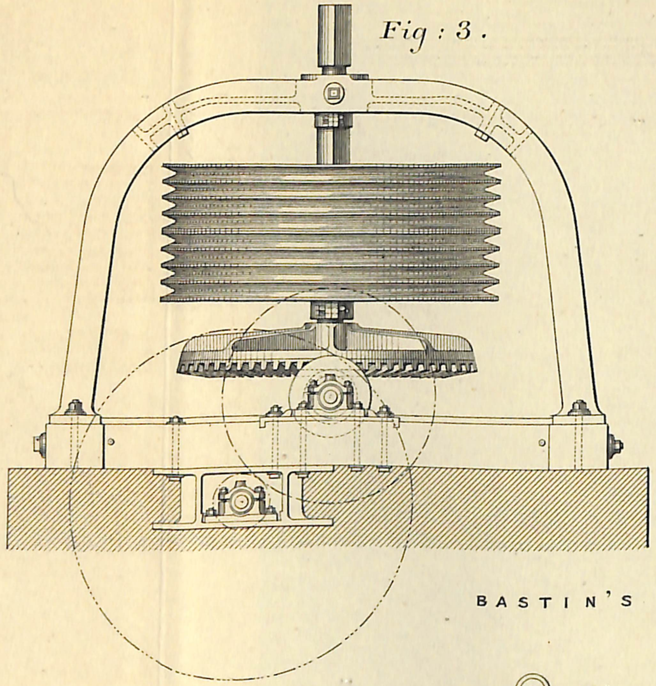
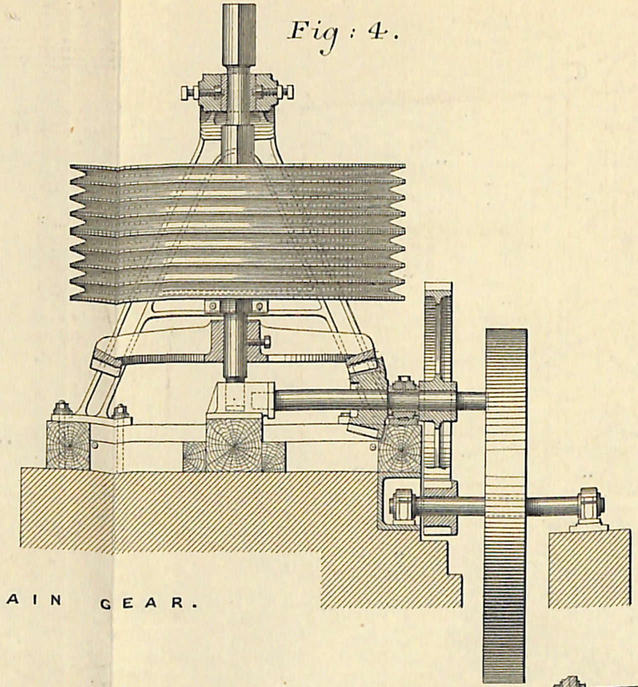


Fig: 4.



BASTIN'S CHAIN GEAR.

Fig: 7.

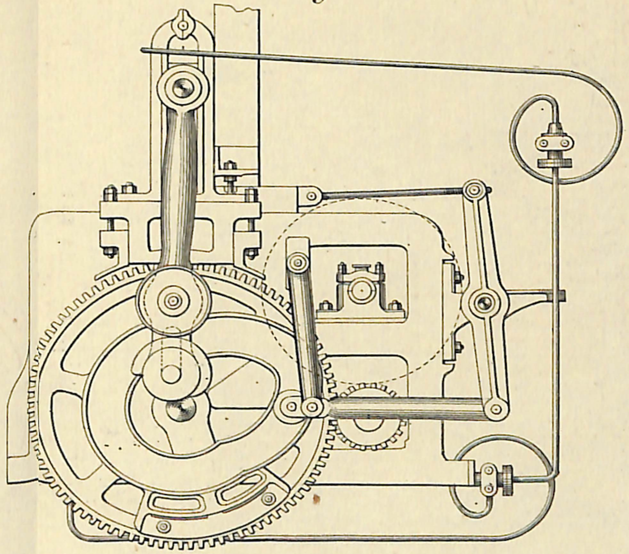
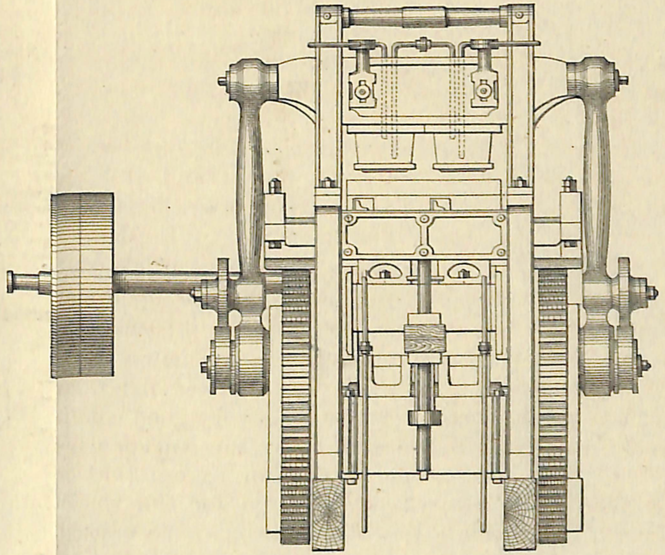


Fig: 8.



WHITTAKER'S MACHINE.

Fig: 5.

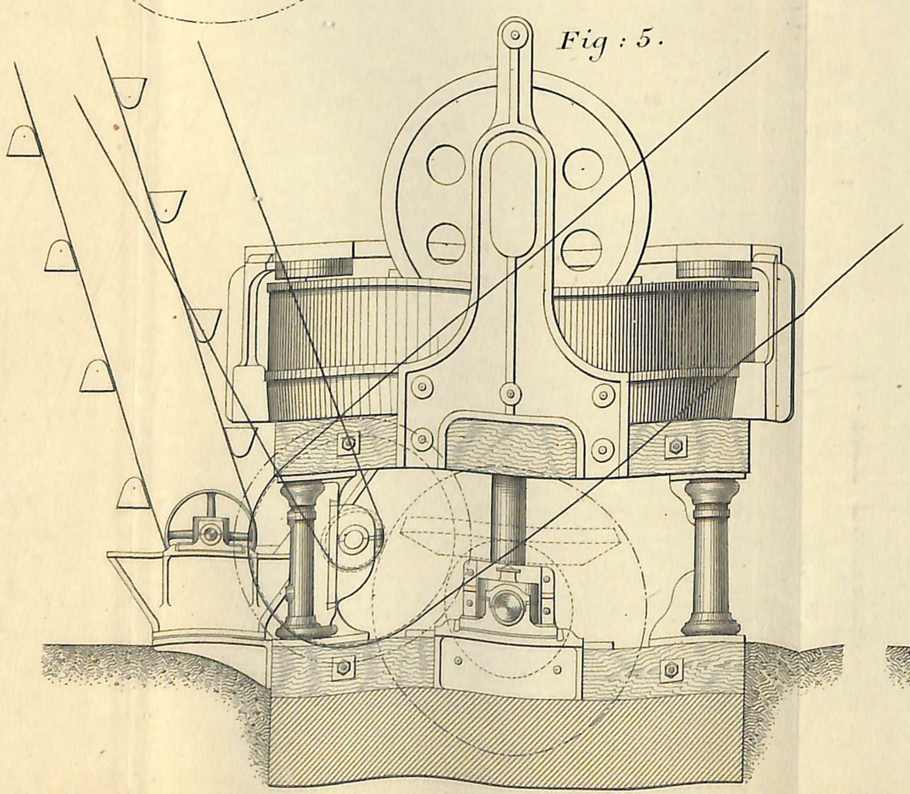
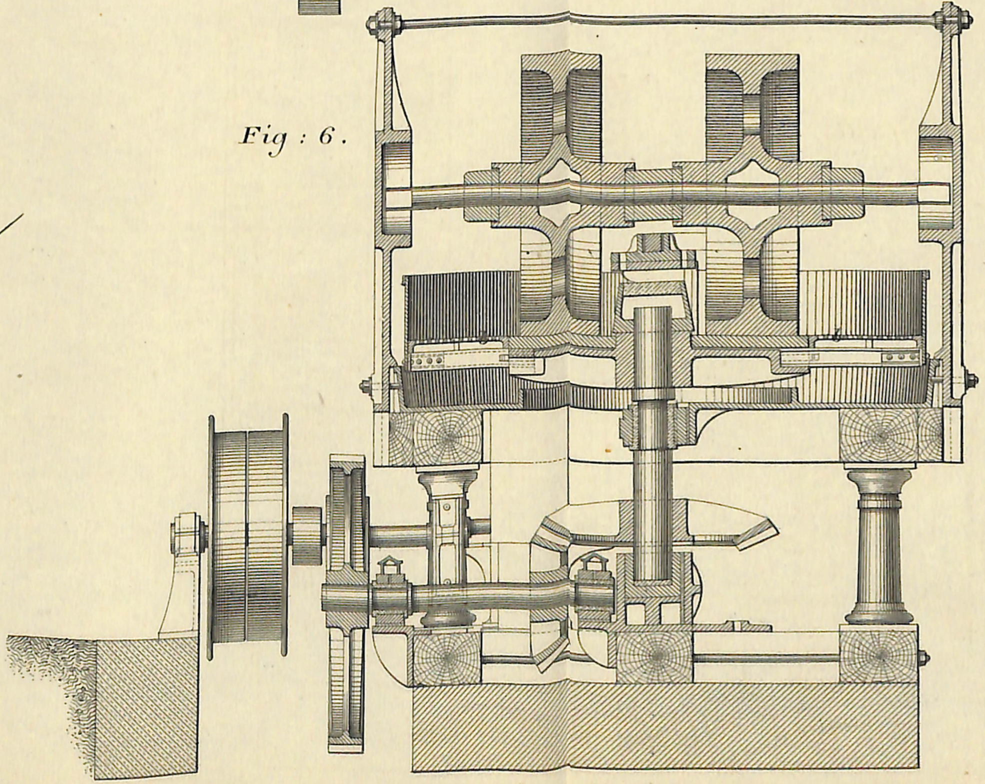
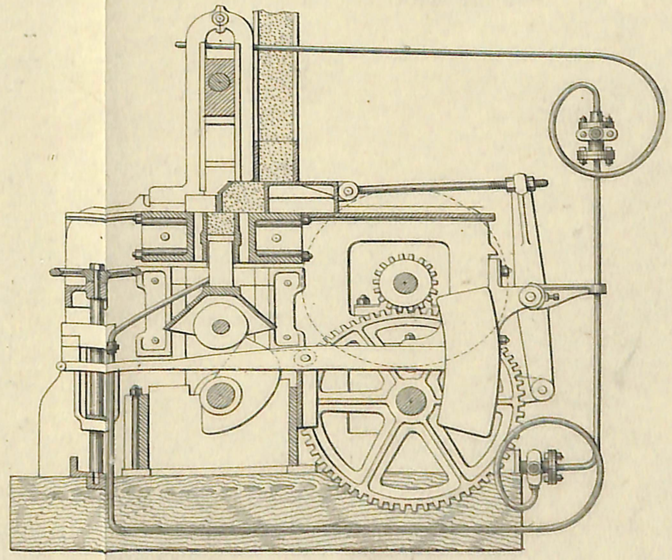


Fig: 6.



SIDE VIEW. BRADLEY & CRAVEN'S PAN MILL. SECTION.

Fig: 9.



WHITTAKER'S MACHINE.

THOS KELL & SON, LITH. 40, KING ST COVENT GARDEN.

Fig: 11.

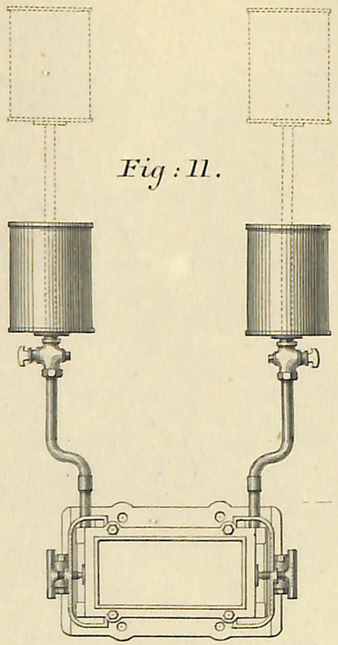
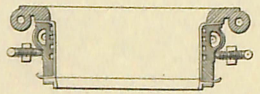
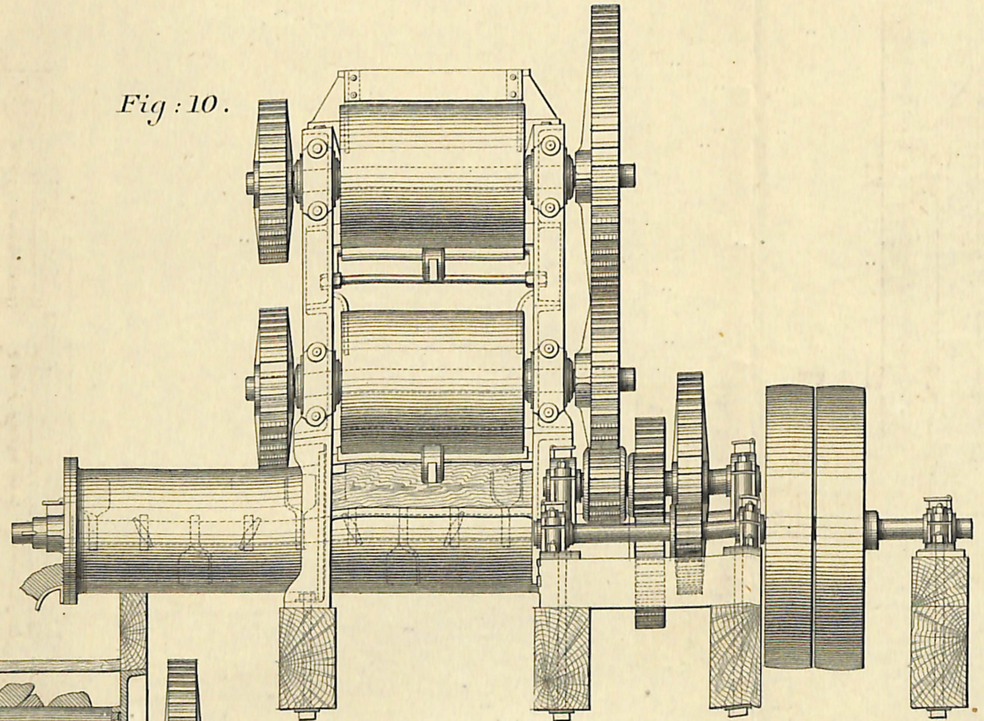


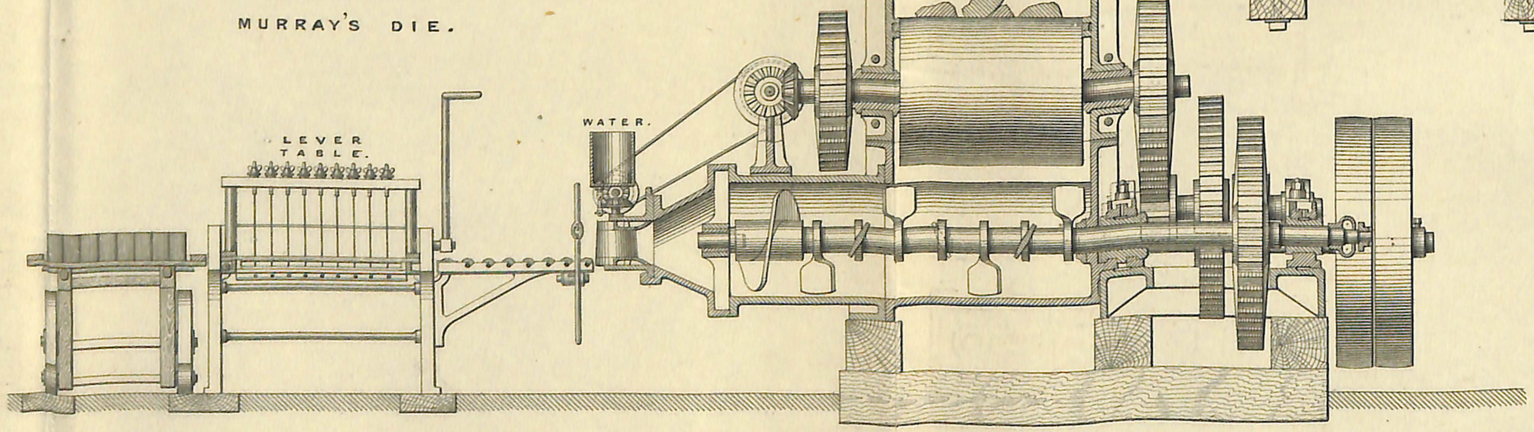
Fig: 12.



MURRAY'S DIE.

Fig: 10.

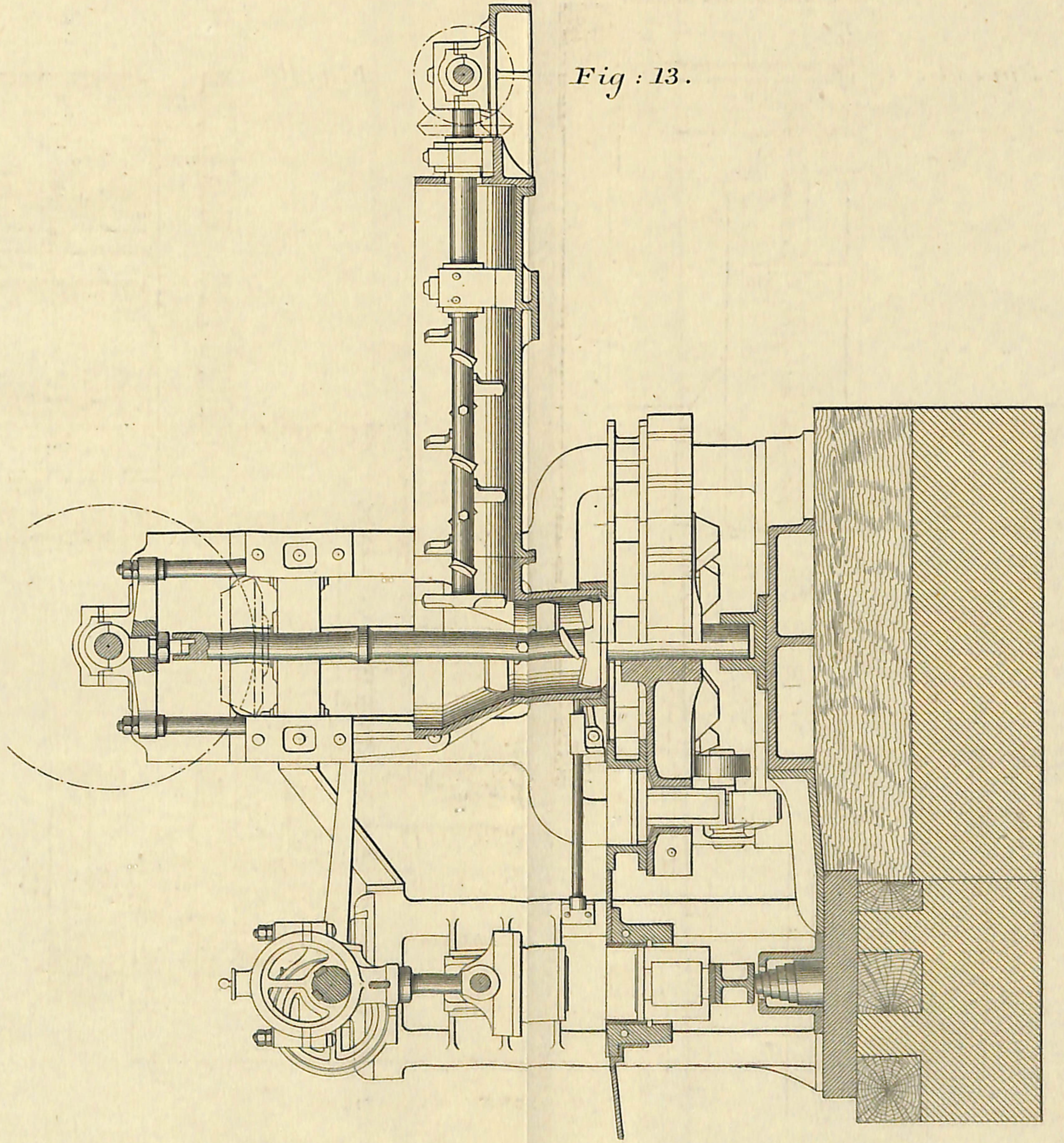




SECTIONAL ELEVATION.

CLAYTON'S BRICK MACHINE.

Fig: 13.

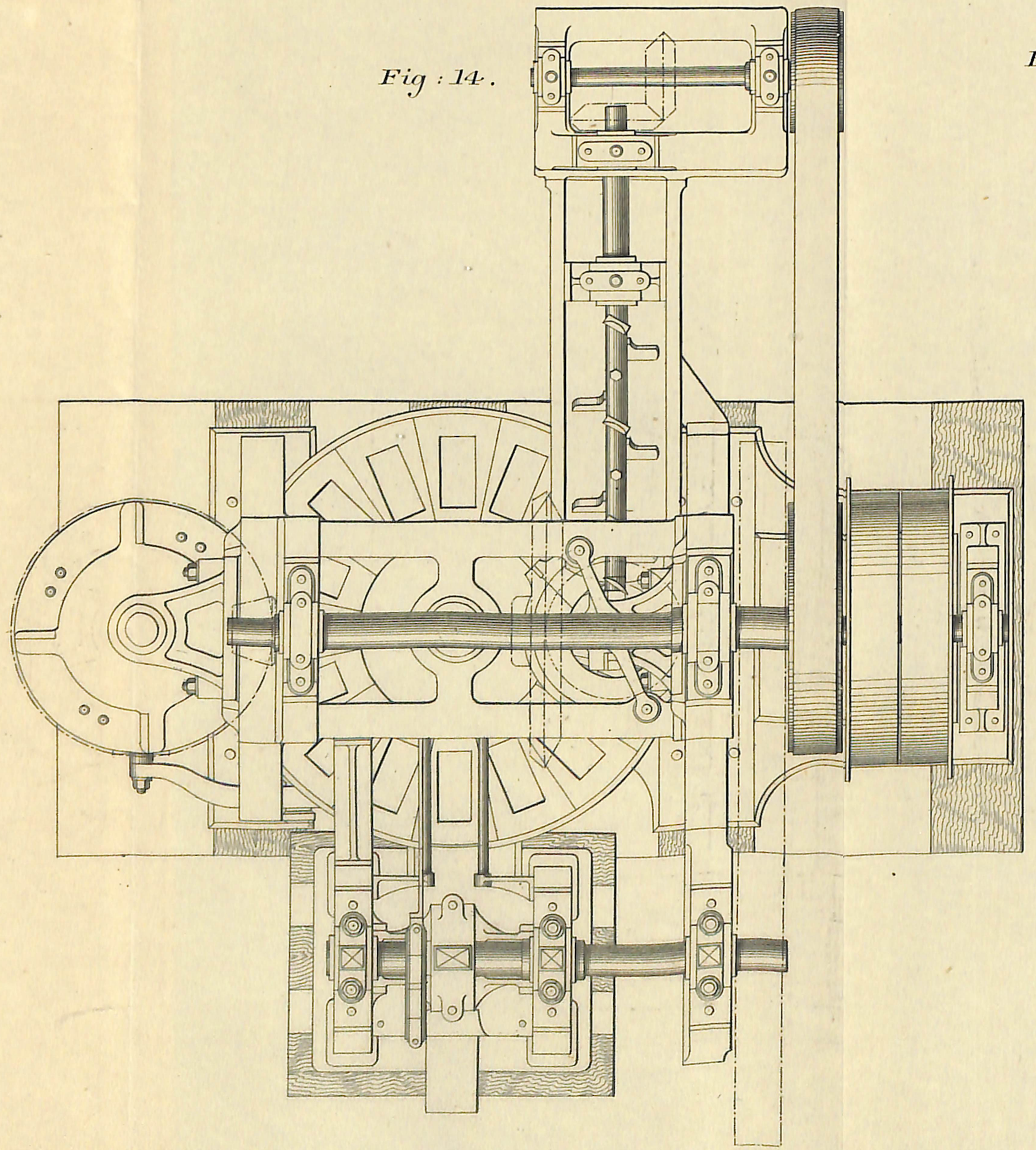


SECTIONAL ELEVATION.

BRADLEY & CRAVEN'S

HENRY WARD, DEL[T]

Fig : 14.



PLAN.

Fig : 15.

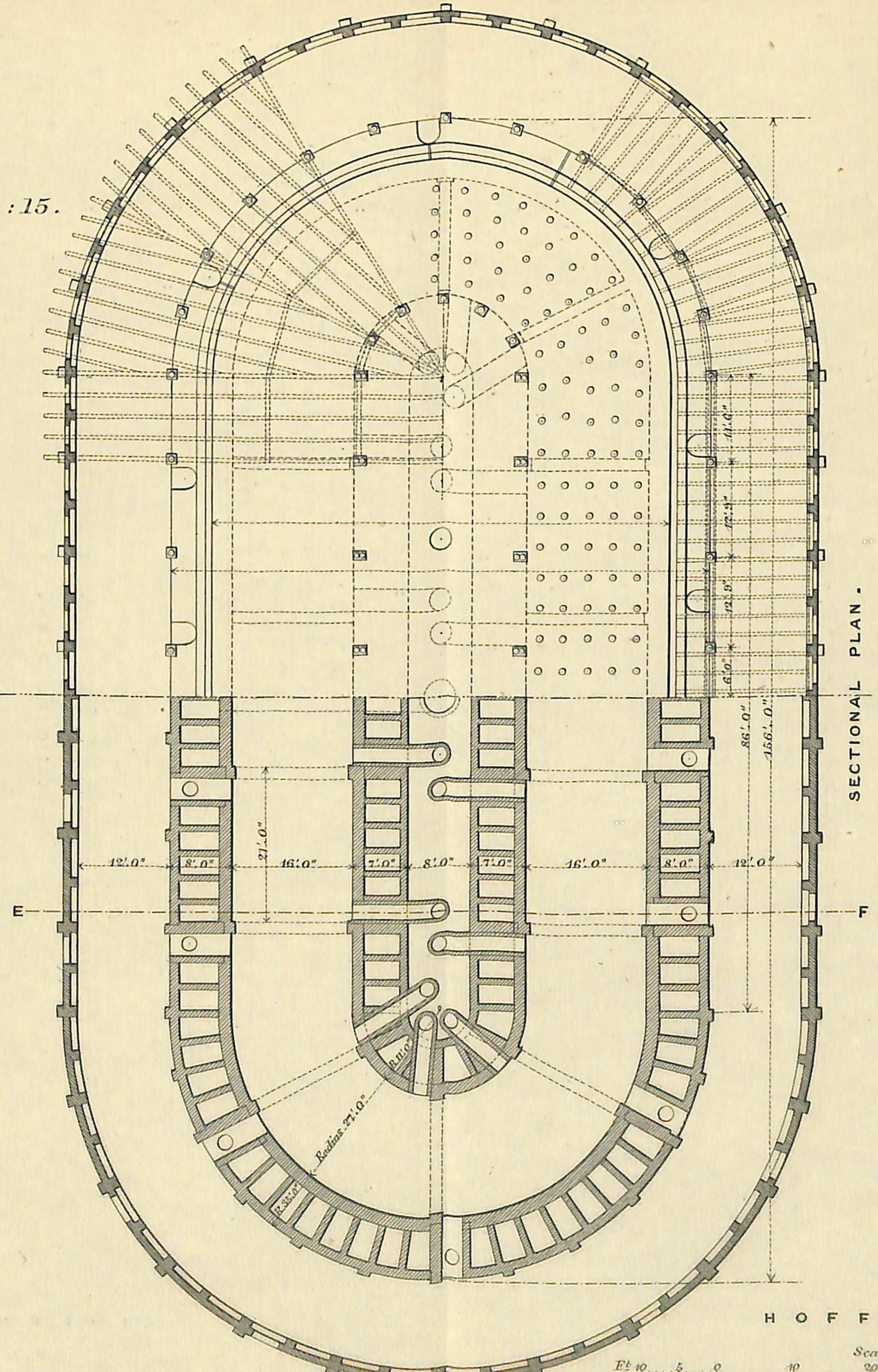


Fig : 16.

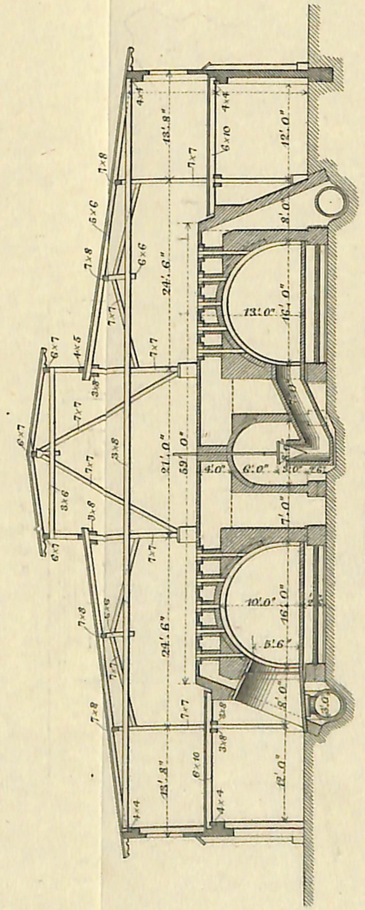
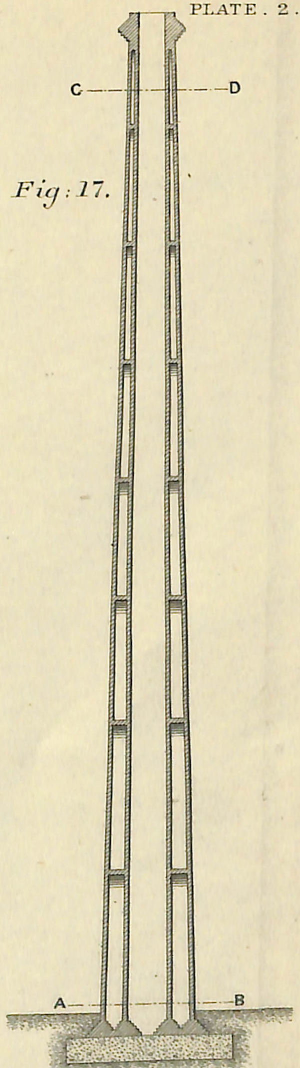
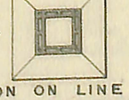


Fig : 17.



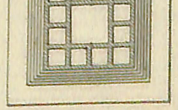
SECTIONAL ELEVATION.

Fig : 18.



SECTION ON LINE C.D.

Fig : 19.



SECTION ON LINE A.B.

BRICK MACHINE.

HOFFMANN KILN.

Scale : 25 Feet = 1 Inch.

Ft 10 5 0 10 20 30 40 50 60 70 Ft

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